SEAMEO Basic Education Standards (SEA-BES): Common Core Regional Learning Standards (CCRLS) in Mathematics and Science

Editors

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FOREWORD

SEAMEO Secretariat takes pride in the publication of the SEA-BES Common Core Regional Learning Standards (CCRLS) in Mathematics and Science under the leadership of SEAMEO RECSAM and its collaborating partners. This publication is an answer to the challenge of what 21st Century science and mathematics education should be and what 21st Century skills, knowledge, understanding, values and attitudes should all learners possess particularly in the development of scientific and technological skills and numeracy skills through education in mathematics and science.

The SEA-BES Common Core Regional Learning Standards (CCRLS) in Mathematics and Science put forth the development and enhancement of 21st century skills comprising of character education, entrepreneurship education, Information and Communications Technology, language and literacy and scientific and technological literacy in all learners. Under the new SEAMEO Education Agenda (2015-2035), SEA-BES CCRLS in Mathematics and Science is re-aligned into Priority Area #7 " Adopting a 21st Century Curriculum."

I fervently hope that Ministries of Education of SEAMEO would take cognizance of the purposes of the SEAMEO Basic Education Standards CCRLS in Mathematics and Science as a tool to strengthen regional collaboration on curriculum standards and learning assessment, curriculum and professional development and a mechanism to enhance competitiveness in the era of globalization, nurturing ASEAN values and spirit and in building a harmonious progressive, peaceful and sustainable ASEAN community.

My sincere appreciation and congratulations to SEAMEO RECSAM, collaborating partner institutions for the expertise and financial support, the consultants, the science and mathematics specialists from SEAMEO sister centres, the Malaysian and Japanese educators, and master/experienced teachers from Penang State for all the hard work and commitment.

Dr. GATOT HARI PRIOWIRJANTO
Director, SEAMEO Secretariat, Bangkok, Thailand

It is widely acknowledged that education potentially serves as a building block towards a nation's progress and development. SEAMEO Member Countries are particularly privileged, sharing a common platform under the spirit of building one 'ASEAN Community'. This ASEAN platform potentially provides for the harmonisation of each SEAMEO Member's national education policy frameworks. Consequently, this raises the education level towards greater heights, through the sharing of knowledge and integration of regional educational ideals and standards.

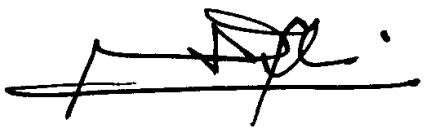
On that thought, it is my honour to represent SEAMEO RECSAM, which initiated the publication of the SEAMEO Basic Education Standards (SEA-BES): Common Core Regional Learning Standards (CCRLS) in Mathematics and Science. This challenging idea of developing a common basic education curriculum was rooted since the inception of the SEAMEO Vision 2010 and reflected in the SEAMEO Strategic Plan 2011-2020. SEAMEO RECSAM has tackled this challenge head-on and is proud to be entrusted with this project which is further aligned with the current seven Priority Areas of SEAMEO Education Agenda (2016-2020) particularly Priority #7 "Adopting a 21st Century Curriculum." SEAMEO RECSAM believes the ASEAN Community provides the opportunity for the development of an educational policy framework for all SEAMEO Member Countries and is confident this project would lead the way forward towards an enhanced access in education opportunities and support in the development of quality basic education particularly in science and mathematics.

In envisaging the challenges of the future, the agreed upon learning standards emphasise and incorporate the 21st century skills that encompass learning, literacy and life skills as well as competencies (OECD,1997). Our societies are continuously changing and the path towards success is progressively adapting according to the political, economic, technological, and social stability demands. In this context, it is hoped that a well-designed curriculum can maximise the development of knowledge and skills that enable individuals to attain holistic well-being, sense of responsibility and self-reliance. Ultimately, successful individuals are able to live harmoniously and further contribute to society.

The process of developing CCRLS was very demanding and challenging yet a rewarding endeavour. As such, I would like to first convey my sincere appreciations to SEAMEO Secretariat for entrusting this monumental

task to SEAMEO RECSAM and for their expertise and financial support. Moreover, I extend a measure of gratitude to Prof. Masami Isoda (CRICED, University of Tsukuba, Japan) for his tireless efforts in providing consultancy in the Mathematics Learning Standards and to Dr. Mark Windale (Centre for Science Education, Sheffield Hallam University, United Kingdom) for his contributions in providing expertise in the Science Learning Standards. Furthermore, I thank Prof. Kerry J. Kennedy (Hong Kong Institute of Education, Hong Kong) for providing valuable inputs that helped shape the learning standards to its current form. These learning standards would not have succeeded without the support and contributions of the science and mathematics curriculum experts from the 11 Ministries of Education, professors, teacher educators and teachers from various institutions in Malaysia and across SEAMEO Member Countries for whom I offer my sincere thanks and appreciation. Acknowledgement is also extended to the Japanese mathematics and science professors who specially travelled from Japan to SEAMEO RECSAM to partake in this project. Likewise, appreciation goes to collaborating partners for their expertise and financial support such as UNICEF EAPRO, British Council Regional Office, British Council Thailand, and the Institute for the Promotion of Teaching Science and Technology, Thailand. Last but not least, I thank the committed and dedicated SEAMEO RECSAM academic and support staff who have contributed directly or indirectly in the development and finalisation of the CCRLS.

I hope the CCRLS in Mathematics and Science will be successful as a tool that will initiate systematic discussion towards the future development of a regional integrated curriculum suitable for ASEAN integration with emphasis on 21st century skills. Moreover, the CCRLS will serve as a platform that encourage the establishment of best practices to overcome differences in curriculum. Ultimately, the CCRLS aimed to strengthen ASEAN collaboration on developing quality curriculum standards and learning assessment which will effectively tackle the changing global context and complexity of ASEAN.



Dr. HJ MOHD JOHAN BIN ZAKARIA, D.J.N.
Centre Director, SEAMEO RECSAM, Penang, Malaysia

It is my pleasure to present the document of SEAMEO Basic Education Standards (SEA-BES): Common Core Regional Learning Standards (CCRLS) for Mathematics and Science. This document is designed to bridge further development activities for educational reforms in SEAMEO Member Countries under the 7 priority areas of the SEAMEO Education Agenda. This three-year project under the purview of SEAMEO RECSAM is also aligned with the movement of the ASEAN Community for "one vision, one identity and one community".

The process of developing SEABES-CCRLS is indeed very challenging and yet a rewarding endeavour right from the initiation until the finalization of the document. On behalf of the project management team, I would like to extend my gratitude and appreciation to all the contributors who had directly or indirectly contributed their effort in realizing the document. Based on the diverse backgrounds and a wide range of expertise gathered from the contributors, the ideas, knowledge, resources, and effort consolidated enable the possibility to develop a leading document for state-of-the-art educational reforms in the region and also to be influential for reforms all over the world under the OECD issues.

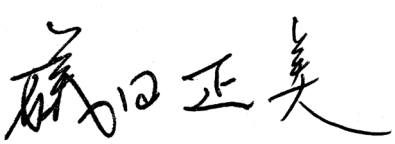
All the preparatory activities organized by SEAMEO RECSAM pertaining to the development of the learning standards had provided ample opportunities for all personnel involved to learn and work together, recognizing the diversities in SEAMEO to describe the curriculum standards for science and mathematics. Specialists from every SEAMEO Member Country were very persevered and committed in the contribution and elaboration, integrating the necessary competencies in mathematics and science for the completion of this document. In relation to the long-term Japanese friendships with ASEAN countries and East Timor, University of Tsukuba, as an affiliate member of SEAMEO contributed a vital role to set the opportunities in establishing and agreeing on the framework of CCRLS at the SEAMEO RECSAM-University of Tsukuba Joint Seminar[1]: Searching for Quality Mathematics Curriculum Framework on the Era of Globalization in February 15-18, 2016. The event was held as the back to back meeting of APEC-Tsukuba International Conference with contributions of curriculum specialists from SEAMEO Member Countries as well as leading researchers in the world[2].

1 The University of Tsukuba, Japan, is an affiliate member of SEAMEO.

2 The APEC Lesson Study Project proposed from Japan (Masami Isoda, University of Tsukuba) and Thailand (Maitree Inprasitha, Khon Kaen University). In the meeting, leading researchers such as the president of International Society of Mathematics Education (IGPME) contributed.

In these engagements, I would like to extend the acknowledgment to the Japanese counterparts and the supporting institutions, particularly in the support of grants from CRICED of the University of Tsukuba and JSPS[3]. I would also like to extend my appreciations to the curriculum specialists from SEAMEO Member Countries who were working very hard and contributing diligently under the flagship of each government, as well as the researchers who had provided the academic commentaries to finalize the document: Colleen M. Eddy, Ivan R. Vysotski, Marsigit, Fumi Ginshima, Mikio Miyazaki, Kimiho Chino, Kotaro Komatsu, Toshinobu Hatanaka, Yoshisuke Kumano, Takeshi Fujita, Kenji Matsubara, Ryugo Oshima, Yoshiyuki Gunji, Izumi Imai, Gabriel Matney, Hee-Chan Lew, Maitree Inprashita, and Shizumi Shimizu.

Last but not least, on behalf of the project management team, I would like to thank the dedicated and committed co-workers in SEAMEO RECSAM who were involved in this project, namely; Pedro Montecillo Jr., Teh Kim Hong, Mohd Sazali bin. Hj. Khalid, Suhaidah Tahir, Nur Jahan Ahmad, and Dominador Dizon Mangao. We had been working together, stretching across different phases for the last three years to finalize this document under the guidance and support of the former director, Hj Mohd Johan Bin Zakaria.



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PREFACE

The Southeast Asian Ministers of Education Organisation (SEAMEO) was established to promote cooperation in education, science and culture in the Southeast Asian region. It is mandated to enhance regional understanding and cooperation and unity of purpose among SEAMEO Member Countries in order to achieve a better quality of life. These mandates are carried out through the establishment of networks and partnerships, the provision of an intellectual forum for policy makers and experts, promotion of sustainable human resource development, enhancement of the capacities of teachers and school managers, and collaboration with global and international organisations, and institutions.

The on-going setting up of the ASEAN Community brings challenges and opportunities that call for dynamic and comprehensive approach among governments in the region. As regional integration progresses, educational institutions are feeling the pressure of working together to bring their systems closer and develop a more comparable, complementary and harmonised programmes and curricula especially in higher education.

To face the reality of the inevitable scenario of regional integration, SEAMEO developed its Strategic Plan (2011-2020) identifying 12 priority initiatives to be pursued in order to achieve the Golden SEAMEO Vision by 2020. The vision is characterised by programme dynamism, excellence, greater prowess, deeper cooperation and enhanced international visibility yet increasing its internal capacity building and striving to create regional standard and social cultural responsibility. SEAMEO has 24 specialist centres called the SEAMEO Centres which carry out these initiatives encompassing capacity building and development, research and development, information and knowledge exchange and management, community work and extension.

SEAMEO RECSAM with its mandate to promote science and mathematics in the Southeast Asian region, led one of the 12 initiatives known as SEAMEO Basic Education Standards (SEA-BES) and Student Networking, which later became two separate projects. The SEA-BES project came into life in November 2014 through a regional consultative meeting back to back with the Southeast Asia Primary Learning Metrics (SEA-PLM) project with funding from UNICEF East Asia Pacific Regional Office (UNICEF EAPRO).

Under the new SEAMEO Education Agenda (2015-2035), SEA-BES project is re-aligned into Priority Area #7 "Adopting a 21st Century Curriculum" which states to pursue a radical reform through systematic analysis of knowledge, skills, and values needed to effectively respond to changing

global contexts, particularly to the ever-increasing complexity of the Southeast Asian economic, socio-cultural and political environment, developing teacher imbued with ASEAN ideals in building ASEAN Community within 20 years.

The SEAMEO Basic Education Standards (SEA-BES) is a regional curriculum project with the purpose of developing learning standards known as the Common Core Regional Learning Standards (CCRLS) in Mathematics and Common Core Regional Learning Standards (CCRLS) in Science. The SEA-BES CCRLS serves the goal of improving the quality of education in the SEAMEO Member Countries through comparison and identification of gaps in terms of curriculum content (i.e. knowledge, skills, attitudes, habits) as well as bases for assessing student learning outcomes. The SEA-BES project envisions to developing common shared and agreed standards for what every learner should know, be able to do and value in mathematics and science. The CCRLS can be used to improve the quality of SEAMEO Member Countries' national curriculum creating equity in curricular provisions across countries and high expectations for all students and learning outcomes that will enable students to contribute productively to their individual countries and their region.

The development of the CCRLS was made possible with the participation and involvement of mathematics and science teachers and experts across the Southeast Asian region and beyond through a series of workshops conducted in-house, local level and regional level as well as international level. The CCRLS was built upon the strength of the existing standards of the SEAMEO Member Countries and further enhanced by the standards of high-performing countries on international student assessments as well as carefully studying the research and literature available on what students need to know, be able to do and value to be successful in post-secondary school, college, career and life.

The publication of SEA-BES Common Core Regional Learning Standards in Mathematics and Science serves as reference to developing the national science and mathematics curriculum of SEAMEO Member Countries in their various efforts of educational reforms. This book publication is comprised of two separate learning standards, namely; the SEA-BES Common Core Regional Learning Standards in Mathematics and SEA-BES Common Core Regional Learning Standards in Science. Both Learning Standards share the same introductory chapter "Vision of SEAMEO and Purpose of CCRLS" but only appears in CCRLS in Mathematics. Each Learning Standard maintains its own set of references.

The SEA-BES CCRLS in Mathematics contains four chapters covering various topics, namely; Framework of CCRLS for Mathematics - Nature of Mathematics, Aims of Mathematics in CCRLS, Components of the Framework, Context to Link the Three Components, Description of Format and Sample Format; Strands in Key Stage 1 – Numbers and Operations, Quantity and Measurement, Shapes, Figures and Solids, Pattern and Data Representations, and Mathematical Process - Humanity; Strands in Key Stage 2 – Extension of Numbers and Operations, Measurement and Relations, Plane Figures and Space Solids, Data Handling and Graphs, and Mathematical Process - Humanity; and Strands in Key Stage 3 – Numbers and Algebra, Relations and Functions, Space and Geometry, Statistics and Probability, and Mathematical Process - Humanity. Mathematical Process-Humanity is embedded in every Strands as well as encompasses mathematical activities aimed to bridge the content standards across the every Key Stage.

On the other hand, SEA-BES CCLRS in Science is consisted of seven chapters, namely; Framework of CCRLS for Science, Science Inquiry Strand, Life and the Living World Strand, Material World Strand, Energy and Change Strand, Earth and Space Strand, and lastly, Science, Engineering and Technology for Sustainable Society Strand. The strands on Science Inquiry, and Science, Engineering and Technology for Sustainable Society may be integrated into the main four content strands. The four content strands serve as the context whereby science content knowledge, scientific skills, processes and thinking, and attitudes and values are developed in the learners across the three Key Stages.

The Learning Standards are intended for use by curriculum makers, educators, teachers, instructional leaders and researchers. Furthermore, the Learning Standards serve as bases to explore high quality mathematics and science teaching, motivate and challenge the development of relevant and meaningful curriculum, pedagogy and learning assessment, and a mechanism to enhance 21st Century skills in the era of globalisation, nurture ASEAN values and spirit to build a harmonious progressive, peaceful and sustainable ASEAN Community.

Editors
Dominador Dizon Mangao
Nur Jahan Ahmad, Ph.D.
Masami Isoda, Ph.D.

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- British Council Regional Office and British Council Thailand; Institute of the Promotion of Teaching Science and Technology-MOE Thailand, and SEAMEO Secretariat for the financial assistance in conducting the 2nd SEA-BES CCRLS Regional Consultative Meeting and Workshop as well as locally organized series of workshops.
- The 11 Ministers of Education of SEAMEO for the financial support.
- Science and mathematics curriculum specialists from the 11 Ministries of Education of SEAMEO for their hard work, time and expertise in the development and finalization of the CCRLS.
- Prof. Masami Isoda, CRICED, University of Tsukuba, Japan and Dr. Mark Windale, Sheffield Hallam University, United Kingdom, consultants in mathematics and science respectively for their expertise, commitment, and dedication in the development of the CCRLS.
- Science and mathematics specialists from SEAMEO centers (i.e. RECSAM, QITEP in Science, QITEP in Mathematics, SEAMOLEC) and national science and mathematics centers (i.e. Institute for the Promotion of Teaching Science and Technology and University of the Philippines-National Institute in Science and Mathematics Education Development) for their technical expertise.

- Mathematics professors and experts from APEC economy members who were present during the APEC-Tsukuba International Conference X and APEC-Tsukuba International Conference XI (Grant No. 26245082 and APEC HRD 03-2015A) such as Colleen M. Eddy, Ivan R. Vysotski, Fumi Ginshima, Mikio Miyazaki, Kimiho Chino, Kotaro Komatsu, Gabriel Matney, Hee-Chan Lew, Maitree Inprashita, and Shizumi Shimizu for their technical expertise.
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Editors
Dominador Dizon Mangao
Nur Jahan Ahmad, Ph.D.
Masami Isoda, Ph.D.

Vision of SEAMEO and Purpose of CCRLS

The goal of regional integration in the development of an 'ASEAN Community' provides the opportunity for the development of an educational policy framework for all SEAMEO Member Countries in order to enhance access to educational opportunities, to support the development of quality basic education and to encourage regional mobility. Such a framework will support all Governments as the main providers of basic education to meet the learning needs of all students.

Indeed the SEAMEO Education Agenda #7 "*Adopting a 21st Century Curriculum*" states to pursue a radical reform through systematic analysis of knowledge, skills, and values needed to effectively respond to changing global contexts, particularly to the ever-increasing complexity of the Southeast Asian economic, socio-cultural, and political environment, developing teacher imbued with ASEAN ideals in building ASEAN community within 20 years (2015-2035). SEAMEO established the Action Agenda from 2016 - 2020 under the 7 priority areas. SEA-BES is one of the projects for action agenda under #7.

SEAMEO Council consisting of the Ministers of Education (2015) enhanced the linking of the seven priority areas with the curriculum and moving towards global citizenship. Inevitably, the region needs the common grounds that allow the stakeholders to develop the fullest potential and capabilities of its citizens. In SEAMEO Member Countries, mathematics and science are major component subjects to be learned. Mathematics can be known as part of the most basic literacy for learning other subjects as well as to think and reason as an independent citizen. Science is known as part of the most necessary literacies for technological and environmental concerns of the society as well as scientific exploration of nature. This document is envisioned to serve as tool for analysing curriculum for 21st century skills, collaboration of ASEAN for changing global context, to produce best practices for reform, systematic discussion for further integration, a platform for curriculum and professional development, and assessment[4].

4 Common Core Regional Learning Standards(CCRLS) is a document for the development of regional curriculum standards which is not the curriculum itself. It is a key reference for further collaboration of the curriculum development, assessments, and professional development on the demands of 21st century which is related with SEAMEO Priorites No.5 and 7. National Curriculum Standards in every SEAMEO Member Countries which are established under every country are respected. The document will be fuctioning for progressive syncronization of curriculum developers and teacher educators in SEAMEO Member Countries directed for ASEAN Community and revised for these demands. For these demands, it is described for curriculum developers and teachers educators.

The 21st century curriculum encompasses learning, literacy and life skills. Competent learners should be able to use tools such as language and technology to convey ideas and thoughts, can act autonomously based on rational decisions and ability to interact well with others in the community. In that context, learners will grow and develop with knowledge and skills that enable them to find jobs, being responsible, self-reliant and contributing to society.

OECD clarified the 21st century skills by the terms of competency (OECD, 2005). It defined competency for successful life and well-functioning society. Societies are continuously changing for seeking success and welfare development. United Nations sets the sustainable development goals (UN, 2015) under the necessity of the development of every society as well as sustainability of social welfare. On this context, Mathematics and Science are necessary subjects in education for success in various fields as well as welfare in our life based on mutual understanding. Mathematics and Science are the tools for overcoming the challenges of diversities in Southeast Asia through developing the competency for competitiveness and understanding others for creating a harmonious society.

The purposes of the Common Core Regional Learning Standards for Mathematics and Science are to develop basic human characters, creative human capital, and well qualified citizens in Southeast Asia for a harmonious society through mathematics and science education. The purposes can be developed and achieved through three major components. Firstly, cultivating basic human characters, values, attitudes and habits of mind are essentials to be developed through mathematics and science. Values are bases for setting objectives of undertakings and making decisions for future directions. Attitudes are mind-sets for attempting to pursue endeavours. Habits of mind develop soft skills which are necessary for living harmoniously in the society. Secondly, for developing creative human capital, process skills need to be developed. Thirdly, knowledge of mathematics and science are essential for cultivating well qualified citizens.

Developing the competency under the three components, includes the selection of necessary content for teaching and context for exploration which encompasses metacognition, critical reasoning and communication. Under the selected content and the context, the three components are well connected and the competency developed through the reflection of the processes. Proficiency in applying competency is also developed through content and context in appropriate situations. Those three components under the context will be clarified by the descriptions of the standard in later chapters.

Based on the preceding background, the purposes of the SEA-BES project were conceptualised in 2015 stated as follows:

Purposes of CCRLS under the SEA-BES Project

The SEAMEO Basic Education Standards initiative would support SEAMEO Member Countries in the following respects:

a) to use it as an analytical tool to support future development of regional integrated curriculum necessary for ASEAN integration with emphasis on 21st century skills;

b) to strengthen ASEAN collaboration on curriculum standards and learning assessment across different educational systems to effectively respond to the changing global context and complexity of ASEAN ;

c) to promote in every member country the establishment of best practices to overcome differences in curriculum;

d) to produce systematic discussion process for the establishment of the regional integrated curriculum and assessment;

e) to use as a platform for curriculum development and professional development for all stakeholders developing teachers imbued with ASEAN ideals in building ASEAN community; and

f) to serve as a platform for assessment such as the Southeast Asia Primary Learning Metrics (SEA-PLM).

On these purposes of the SEA-BES project, CCRLS defines the standards on mathematics and science based on the following principles:

i. The standards are the common ground to develop the fullest potential and capabilities to acquire competency in the 21st century.

i. The standards are presumed for competitiveness in this globalization era and understanding others in creating the ASEAN harmonious society under global citizenship.

ii. The standards serve as tools for analysing curriculum for the purpose of the project as stated in (a) to (f).

Those principles are elaborated for a well-functioning ASEAN societies taking into account the cultural differences and development disparity. The standards for mathematics and science will be discussed separately at the later chapters.

Development Process of CCRLS

SEA-BES Project Framework in 2014

SEA-BES Project was initiated in 2014 before the establishment of the 7 Priority Areas and as response for the SEAMEO College Project for preparation of the ASEAN Community. The original conceptual framework is shown in Figure 1.

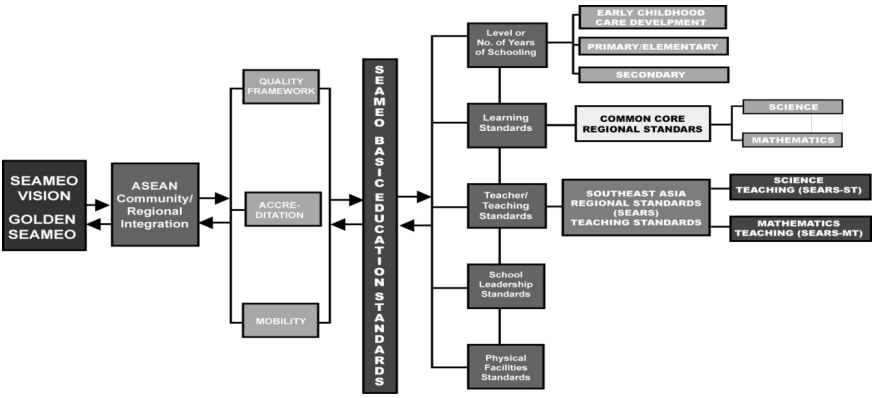

Figure 1. The position of the CCRLS under the SEA-BES project framework.

Methodology to Develop CCRLS

Figure 2 shows the original flow process of the development of the common core regional learning standards in mathematics and science.

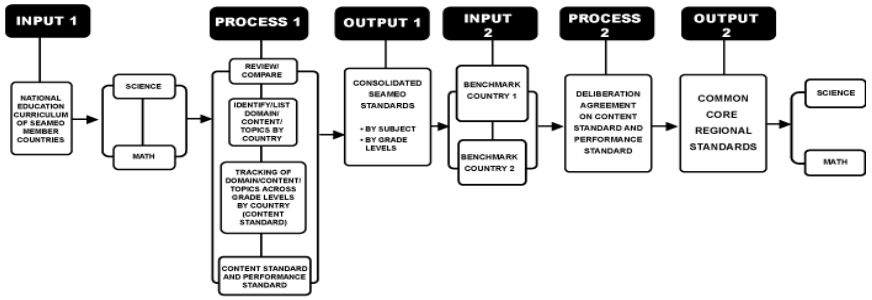

Figure 2. Framework in developing the CCRLS in Mathematics and Science for SEA-BES (Mangao, Tahir, and Zakaria, 2015).

The CCRLS was developed based from the strengths of the existing national education standards of the SEAMEO Member Countries. The various activities in the development of the CCRLS document for Mathematics and Science undertook the following processes:

- curriculum review and comparison of the national education curriculum of the seven SEAMEO Member Countries in Mathematics and Science, namely; Brunei Darussalam, Cambodia, Indonesia, Malaysia, Philippines, Singapore and Thailand;
- identification of similarities and differences in terms of content/domain/ topics/strand/year level by country; and
- tracking of content/domain/topics/strands across grade levels from the primary to secondary level.

There are diversities among SEAMEO Member Countries. The year levels are not always the same. Thus, the CCRLS in Mathematics and Science documents are categorised into three key stages: Key Stage 1 covers Grades 1 to 3, Key Stage 2 covers Grades 4 to 6 and Key Stage 3 covers Grades 7 to 9.

Other activities undertaken include the development of the appropriate strands for every stage and the topics under the strand and the elaboration of every standard description under the participation of representatives from Member Countries (including Myanmar, Vietnam, Lao PDR and Timor Leste) and other leading researchers from non-SEAMEO Member Countries such as APEC Economies.

The consolidated SEAMEO Mathematics and Science Standards were benchmarked with the standards of high qualified education countries/ economies such as Hong Kong, Japan, Australia, United Kingdom and the U.S.; reviewed documents such as Trends in International Mathematics and Science Study (TIMSS), Programme for International Student Assessment (PISA), and National Council of Teachers of Mathematics (NCTM) as well as research studies and literature available related to curriculum development.

Standards found in every stage are useful for every country to engage in their own activity on purposes (a) to (f) especially for considering the experiment and challenges for every country's reform.

Series of SEA-BES Workshops

A series of workshops which aimed to develop the Common Core Regional Learning Standards (CCRS) in Mathematics and Science were conducted on different dates, levels and venues as follows:

A. National Level

- 2 April 2015 (In-house/Local Level, SEAMEO RECSAM, Malaysia)
- 11 May 2015 (In-house/Local Level, SEAMEO RECSAM, Malaysia)
- 21-22 May 2015 (In-house/Local Level, SEAMEO RECSAM, Malaysia)
- 23 July 2015 (In-house/Local Level, SEAMEO RECSAM, Malaysia)
- 27 August 2015 (In-house/Local Level, SEAMEO RECSAM, Malaysia)
- 17 September 2015 (In-house/Local Level, SEAMEO RECSAM, Malaysia)
- 27-28 January 2016 (In-house/Local Level, SEAMEO RECSAM, Malaysia)
- 24-25 March 2016 (In-house/Local Level, SEAMEO RECSAM, Malaysia)

B. Regional Level

- 4-5 November 2014 (Regional Level, SEAMEO RECSAM, Malaysia)
- 20-22 October 2015 (Regional Level, SEAMEO RECSAM, Malaysia)
- 15-18 February 2016 (Regional Level, University of Tsukuba, Japan – Only for Mathematics Standards)
- 9-12 February 2017 (Regional Level, University of Tsukuba, Japan – Only for Mathematics Standards)
- 28-30 March 2017 (Regional Level, SEAMEO RECSAM, Malaysia)

Participation and Involvement of Experts, Educators and Institutions

Maximum participation and involvement of experts and teachers across the Southeast Asian region and beyond were solicited in the development of the CCRLS document. Their tasks include being a member of curriculum working group giving inputs and providing specific, constructive feedback on the draft Standards. The following groups were involved:

- Consultants (Professor Masami Isoda, Center of Research on International Cooperation in Educational Development, University of Tsukuba, Japan; Dr. Mark Windale, Centre for Science Education, Sheffield Hallam University, United Kingdom; and Professor Kerry J. Kennedy, Hong Kong Institute of Education, Hong Kong)
- Curriculum experts in science and mathematics from the 11 Ministries of Education of SEAMEO Member Countries
- SEAMEO Secretariat
- Science and mathematics specialists from SEAMEO centres (i.e. RECSAM, QITEP in Science, QITEP in Mathematics, SEAMOLEC)
- Mathematics professors and experts from APEC economy members who were present during APEC-Tsukuba International Conference X and APEC-Tsukuba International Conference XI (Grant No.26245082 and APEC HRD 03-2015A)
- Science and mathematics professors and curriculum specialists from Japan under the project of Japan Society for Promotion of Science (JSPS-Grant No.16K13563 and 26245082)
- Science and mathematics professors and lecturers from Malaysian educational institutions (i.e. Universiti Sains Malaysia (USM), Universiti Pendidikan Sultan Idris (UPSI), Institut Pendidikan Guru (IPG) – Kampus Pulau Pinang, Kampus Tuanku Bainun and Kampus Ipoh) in Malaysia
- Science and Mathematics National Centres (i.e. Institute for the Promotion of Teaching Science and Technology (IPST), University of the Philippines-National Institute for Science and Mathematics Education Development (UP-NISMED)
- Elementary and secondary science and mathematics master and experienced teachers from Penang State

COMMON CORE REGIONAL LEARNING STANDARDS IN MATHEMATICS

Chapter 1

Framework for CCRLS in Mathematics

The first chapter describes the direction of CCRLS for creating a harmonious society of ASEAN in this competitive era through mutual understanding. The CCRLS serves as a tool to develop basic human characters, creative human capital, and well qualified citizens through mathematics and science. The direction of CCRLS describes three major components. Firstly, for cultivating basic human characters through mathematical values, attitudes and habits of mind. Secondly, for developing creative human capital, process skills need to be developed. Thirdly, knowledge of mathematics and science are for cultivating well qualified citizens. For clarifying how these three components function within the mathematics framework, the nature of mathematics is considered initially and the aims of CCRLS in mathematics are deduced from it. Lastly, the format of describing the CCRLS in mathematics will be shown before elaboration of every standard.

Nature of Mathematics

Mathematics has been recognized as a necessary literacy for citizenship and not only living economically but also to establish a society with fruitful arguments and creations for better living. It has been taught as a basic language for all academic subjects using visual and logical-symbolic representations. In this information society, mathematics has increased its role to establish 21st century skills through reviewing mathematics as the science of patterns for future prediction and designing with big data which produces innovation not only for technology advancement but also for business model.

Mathematics is an essential subject to establish common reasoning for sustainable development of society through viable argument in understanding each other and develop critical reasoning as the habits of mind. Mathematics should be learned as basis for all subjects. For clarifying the framework in CCRLS on mathematics and by knowing the role of mathematics education, the humanistic and philosophical natures of mathematics are confirmed as follows;

Humanistic nature of mathematics is explained by the attitudes of competitiveness and understanding of others by challenging mathematicians such as Blaise Pascal, Rene Descartes, Isaac Newton and Gottfried Wilhelm Leibniz. For example, if you read the letter from Pascal to Pierre de Fermat you recognize competitive attitude of Blaise Pascal to Fermat's intelligence and seeking the way to be understood by his Excellency of his finding on Pascal's

Triangles. If we read the Pascal's pensee you recognize how Pascal denies Descartes geometry using algebra from the aspect of ancient Greek geometry. On the other hand, Descartes tried to overcome the difficulties of ancient geometry by algebra. If you read the letter from Descartes to Elisabeth, you recognize how Descartes appreciated and felt happy when the Royal Highness Elisabeth used his ideas of algebra in geometry. Despite being a princess, Elisabeth had been continuously learning mathematics in her life.

There were discussions on who developed calculus between Britain and Continental mathematician. On that context, Johann Bernoulli, a continental mathematician, posed a question on the journal about the Brachistochrone problem, locus of the point on circumference of the circle when it rotates on the line. No one replied and Bernoulli extended the deadline of the answer and asked Newton to reply. Newton answered it within a day. Finally, six contributions of the appropriate answer including Newton and other Continental mathematicians were accepted. All those stories show that mathematics embraces the humanistic nature of proficiency for competitiveness and understand others for sharing ideas.

Philosophical nature of mathematics can be explained on ontological and epistemological perspectives. On the ontological perspective, mathematics can be seen as a subject for universal understanding and common scientific language. Plato and Aristotle are usually compared on this perspective. Plato believes that the existence of the world of "idea" and mathematics existed in the world of "idea" on Platonism. On this context, mathematical creation is usually explained by the word "discover" which means taking out the cover from which it has already existed. At the moment of discovery, reasonable, harmony and beautifulness of mathematical system is usually felt. Aristotle tried to explain about reaching idea from the "material" to the "form". This explains that abstract mathematics can be understood with concrete materials using terms such as "modelling", "instruments", "embodiment", "metaphor" and "change representation". From both ontological and epistemological perspectives, mathematics can be understandable and acquirable by everyone and if acquired, it serves as a common scientific language which is used to express in any subjects. Once representing the ideas using the shared common language, the world can be possibly perceived in the same view autonomously.

On the epistemological perspective, mathematics can be developed through processes which are necessary to acquire mathematical values and ways of thinking. From this perspective, idealism and materialism are compared. On the context of Hegel, a member of German idealism, Imre Lakatos explained the development of mathematics through proof and refutation. On his context,

mathematics is not fixed but an expandable system that can be restructured through a process of dialectic in constructing viable arguments. Plato also used dialectic for reaching ideas with the examples of mathematics. The origin of dialectic is known as the origin of indirect proof. In education today, dialectic is a part of critical thinking for creation. Parallel perspectives for mathematical developments are given by George Polya and Hans Freudenthal. For the discovery of mathematics, Polya explained mathematical problem solving processes with mathematical ideas and mathematical ways of thinking in general. Freudenthal enhanced the activity to reorganize mathematics by the term mathematization.

Genetic epistemologist Jean Piaget established his theory for operations based on the various theories including Freudenthal's discussion and explained mathematical development of operations by the term reflective abstraction. Reflection is also a necessary activity for mathematization by Freudenthal. On materialism, under Vygotskyian perspective, intermediate tools such as language become the basis for reasoning in the mind. Under his theory, the high quality mathematical thinking can be developed depending on the high quality communication in mathematics classrooms. Dialectical-critical discussion should be enhanced in the mathematics class. From both epistemological perspectives, mathematics can be developed through the processes of communication, problem solving and mathematization which include reorganization of mathematics. Those processes are necessary to acquire mathematical values and ways of thinking through reflection.

Aims of Mathematics in CCRLS

The aims of mathematics in CCRLS for developing basic human characters, creative human capital, and well qualified citizens in Southeast Asia for a harmonious society through mathematics are as follows:

- Develop mathematical values, attitudes and habits of mind for human character,
- Develop mathematical thinking and enable to produce appropriate process,
- Acquire proficiency in mathematics content and apply mathematics in appropriate situations.

Framework for CCRLS in Mathematics as shown in Figure 3 is developed under the three components and the discussion of humanistic and philosophical nature of mathematics. The framework also provides the concrete ideas of mathematics learning on the above aims.

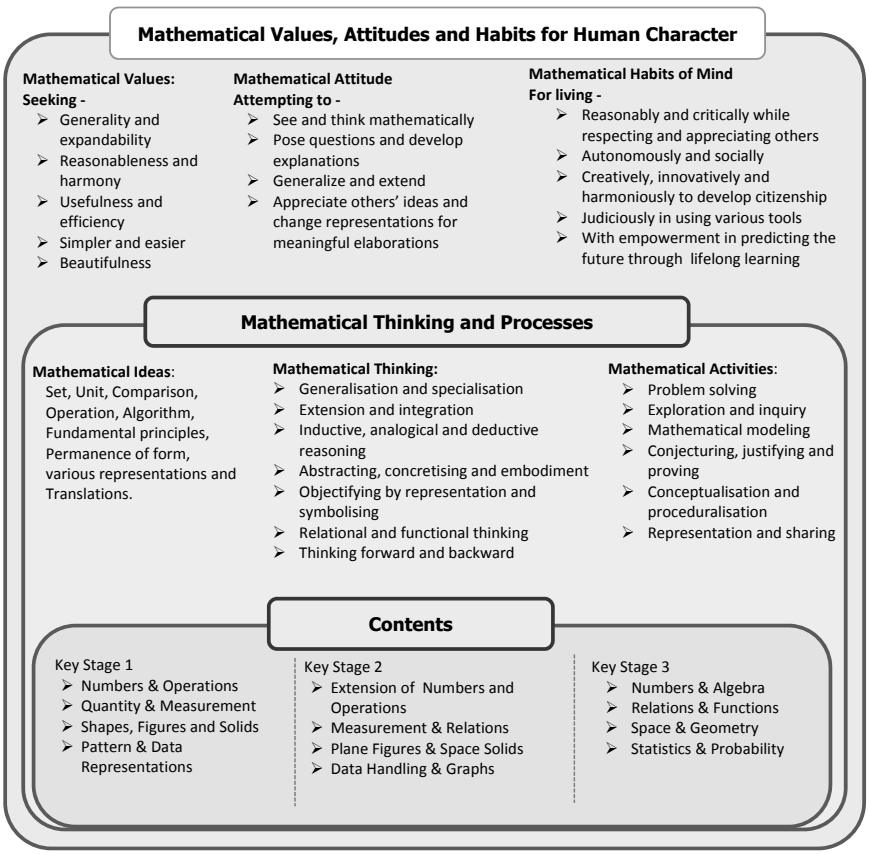

Figure 3. CCRLS Framework for Mathematics.

Mathematical Values, Attitude and Habits for Human Character

For cultivating basic human characters, values, attitudes and habits of mind are essentials to be developed through mathematics. Values are basis for setting objectives and making decisions for future directions. Attitudes are mind-sets for attempting to pursue undertakings. Habits of mind are necessary for soft skills to live harmoniously in the society. Mathematical values, mathematical attitudes and mathematical habits of mind are simultaneously developed and inculcated through the learning of the content knowledge.

Essential examples on values, attitudes and habits of mind are given in Figure 3. On values, in mathematics, generalizable and expandable ideas are usually recognised as strong ideas. Explaining why such as proving is necessary in mathematics, then it is usually seeking reasonableness. Harmony and beautifulness are described not only in relation to mathematical arts, but also in science of patterns and the system of mathematics. Usefulness and simplicity are used in selection of mathematical ideas and procedures.

On mathematical attitudes, "seeing and thinking mathematically" means attempting to use the mathematics learned for seeing and thinking the objects. Posing questions and providing explanation such as the "why" and the "when" are ordinary sequence for thinking mathematically. Changing representation to other ways such as modelling can overcome the running out of ideas in problem solving. The mindset for trying to understand others is the basis to explain own ideas that is understandable to the rest with appreciation. Producing the concept with definition operationally is a manner of mathematics.

On habits of mind for citizens to live, mathematical attitudes and values are necessary to reason out critically and reasonably. Appreciating and respecting other ideas is also necessary. Mathematics is developed independently for those who appreciate life creatively, innovatively and harmoniously. Seeking the easier and effective manner selection of appropriate tools is necessary. Mathematics as a subject to challenge and experience competitiveness, appreciation with others, develop the mindset for lifelong learning, personal development and social mobility.

Mathematical Thinking and Processes

For developing creative human capital, mathematical ideas, mathematical thinking and mathematical activities are essential. Mathematical ideas are process skills involving mathematical concepts. Mathematical thinking is mathematical way of reasoning in general which does not depend on specific concepts. Mathematical activities are various types of activities such as problem solving. Mathematical processes which include these components are necessary skills to use mathematics in our life, such as innovation in this society (e.g. Internet of Things (IOT)). In the context of education, competency referring to mathematical processes is basis for STEM and STEAM[5] education as well as basis for social science and economy education.

Mathematical ideas serve as the basis of content knowledge related to promoting and developing mathematical thinking. Some key ideas of mathematics are used as special process. The fundamental ideas of set and unit lead to a more hierarchical and simple structural relationship. The ability to compare, operate, and perform algorithm of related functions enables efficient ways of learning mathematics and solving problem in life with mathematics.

In the case of set, set as mathematical ideas is related with conditions and elements. It is related with activity in grouping and distinguishing with other groups by conditions. Example, 3 red flowers and 4 white flowers become 7 flowers, if we change the condition of the set by not considering the colours. "A and non A" is a simple manner to distinguish sets with logical reasoning. For categorizing, we use intervals such as $x > 0$, $x < 0$, $x = 0$. This situation can be seen in the hyperbolic graph where $y=1/x$.

In the case of unit, it is a mathematical idea that is related with the process to produce and apply the unit with operations. On some cases, trying to find the common denominator is the way to find the unit of two given quantity. Tentative unit such as arbitrary units can be set and applied locally whereas standard units are used globally. In the combination of different quantities it produces new measurement quantity such as distance with respect to time produce speed. Square unit such as square centimetres is a unit for area.

Mathematical thinking is well discussed by George Polya. Inductive, analogical and didactical reasoning are major logical reasoning at school however, didactical reasoning is enhanced in relation to formal logic and inductive and analogical reasoning are not well recognized. Polya enlightens the importance of those reasoning in mathematics. On the process of mathematization by

5 *STEM refers to Science, Technology, Engineering and Mathematics. STEAM refers to Science, Technology, Engineering, Arts and Mathematics or Applied Mathematics.*

Hans Freudenthal, objectifying of the method is necessary. David Toll mentioned it by the term thinkable concept on the process of conceptual development. Polya mentioned thinking forward and backward in relation to ancient Greek term analysis.

Mathematical activities are ways to represent mathematical process. Problem solving process was analysed by Polya. He influenced encompassing problem solving with various strategies. Technology enhances the activities of conjecturing and visualizing for inquiries. Conceptualization is done based on procedures such as the procedure 3+3+3+3=12, become the basis for 4x3. The proceduralization of multiplication is done through developing the multiplication table, idea of distribution and memorizing.

Content

For cultivating well qualified citizens, content knowledge of mathematics is essential. Content of mathematics is usually divided by the set of mathematics. However, for developing human characters and creative human capitals, it should be developed through the mathematical processes. Values, attitudes and habits of mind are driving force to engage in mathematical processes. Thus, without involving human character formations with mathematical process skills, content knowledge of mathematics cannot be realised. The content is divided into three stages in CCRLS and every stage has four strands. Between the stages, the names of the strands are directly connected. However, on the standard level, content standards are well connected. The names of strands for every key stage are as follows:

Key Stages	Strands
Key Stage 1	Numbers and Operations Quantity and Measurement Shapes, Figures and Solids Pattern & Data Representations
Key Stage 2	Extension of Numbers and Operations Measurement and Relations Plane Figures & Space Solids Data Handling and Graphs
Key Stage 3	Numbers and Algebra Relations and Functions Space and Geometry Statistics and Probability

In every stage, four content strands are mutually related[6]. Between key stages, all strands in different key stages are mutually related. The same content strand names are not used to indicate development and reorganization beyond each stage. For example, "Numbers and Operations" in Key stage 1, "Extension of Numbers and Operation" in Key stage 2, and "Numbers and Algebra" in Key stage 3 are well connected. These names of the content strands show the extension and integration of content. For example, even and odd numbers can be taught at any stages with the different definition. At Key stage 1 even numbers can be introduced "counting by two" which does not include zero. In Key stage 2 it can be re-defined by a number divisible by two. Finally, in Key stage 3 it can be re-defined multiple of two in integers which includes zero. Although we use the same name as even number, they are conceptually different. Key stage 1 definition is based on the counting, Key stage 2 is based on division while Key stage 3 is based on algebraic notation[7]. For expressing such theoretical differences, name of strands for content should be distinguished. In the case of measurement, there is no strand name of measurement in Key stage 3. Key stage 1 relates with quantity and setting the units. In Key stage 2, it extends to non-additive quantity beyond dimension. In Key stage 3 the idea of unit and measurement is embedded in every strand. For example, square root in Number and Algebra strand is an irrational number which means unmeasurable. Pythagorean Theorem in Space and Geometry strand is used for measuring proportional function in Relations and Functions strand which is used for counting the number of nails by weight, and in Statistics and Probability strand, new measurement units are expressed such as quartile for boxplot.

Context to Link the Three Components

Three components in Figure 3 should be embedded in every key stage as standards for the content of teaching. "Mathematical values, attitudes, habits for human character" component and "Mathematical thinking and processes" component cannot exist without "Content" component. The first two components can be taught through teaching with the content. For teaching those three components at the same time, context is introduced as shown in Figure 4.

6 Strands used to explain mutual relation of content (Jeremy Kilpatrick, Jane Swafford, Bradford Findell. "Adding it up", National Academies Press. 2001).The term domain is sometimes used for compartmentalization through categorization of content.

7 In algebraic notation of numbers, addition and multiplication are major operations. Subtraction can be represented by addition of negative numbers and division can be represented by reciprocal or multiplicative inverse property.

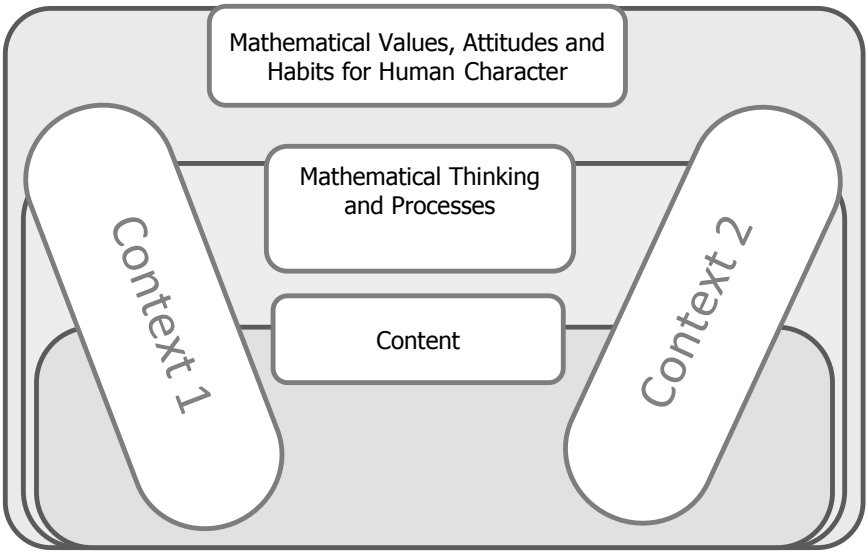

Figure 4. Interlinking of the three components with the context.

On the given context, three components are well connected. On this reason, classroom activities for developing competencies should be designed to link them. The following contexts are samples:

- Explore a problem with curiosity in a situation and attempting to formulate mathematical problems
- Apply the mathematics learned, listen to other's ideas and appreciate the usefulness, power and beauty of mathematics
- Enjoy classroom communications on mathematical ideas in solving problems with patience and develop persistence
- Feel the excitement of "Eureka" with enthusiasm for the solutions and explanation of unknown problems
- Think about ways of explanation using understandable representations such as language, symbols, diagrams and notation of mathematics
- Discuss the differences in seeing situations before and after learning mathematics
- Explain, understand others and conclude mathematical ideas

- Explore ideas through inductive and deductive reasoning when solving problems to foster mathematical curiosity
- Explore ideas with examples and counter examples
- Feel confident in using mathematics to analyse and solve contextual problems both in school and in real-life situations
- Promote knowledge, skills and attitudes necessary to pursue further learning in mathematics
- Enhance communication skills with the language of mathematics
- Promote abstract, logical, critical and metacognitive thinking to assess their own and others' work
- Foster critical reasoning for appreciating other's perspectives
- Promote critical appreciation on the use of information and communications technology in mathematics
- Appreciate the universality of mathematics and its multicultural and historical perspectives

Those contexts are chosen for illustrating the interwoven links of the two components with contents. It looks methods of teaching however all three components are the subject of teaching on the contexts.

Descriptions Format for SEA-BES CCRLS in Mathematics

Curriculum standards in every country are written under specific format for all school subjects under the regulation and policy of the Ministry of Education in every country and with direction of curriculum reform. The format itself embedded the direction of national reform of movement itself.

The format of writing the CCRLS is produced under Figures 3 and 4, and the content standards and the process-humanity strands with the defined context as follows:

Each key stage has four content strands and one mathematical process-humanity strand. The content strands describe the content standards. The mathematical process-humanity strands describe the elements covered under mathematical thinking and process component, and values, attitudes and habits of human character component in Figure 3. The word "process" refers to the mathematical thinking and processes discussed in Figure 3. The word "humanity" refers to the elements in the components of mathematical values, attitude and habits. The mathematical process-humanity standards of each key stage imply the context for learning those two components. The descriptions of

every standard under the process-humanity strands are commonly discussed across different content strands[8] within the same key stage.

Mathematical process-humanity strand includes three processes (Mathematical Ideas, Thinking and Activities) and the three humanities (Mathematical Values, Attitudes and Habits of mind for Citizen to live).

The above contexts shown explain three processes for developing mathematics such as: Argumentation for understanding others and develop sophistication through critique; and Applying mathematics through modelling and replacement. Extension and generalization are essential elements for developing mathematics.

In argumentation, producing understandable explanations are usually related to understandable representation such as diagram and materials for showing the simple structure. Example is used for demonstration of specific case and counter example is used for checking generality. Process of modelling usually includes problem formation, solving mathematically, and explaining the meaning. Within these three processes, three humanities such as recognizing beautifulness of patterns are learned through the appreciation of mathematical experiences, appreciation of other's ideas also includes understanding ideas with sense such as recognize the usefulness of idea or otherwise.

Under those explanations, the writing format is defined with content standards and process-humanity standards. It includes the choosing of necessary content for teaching and exploratory sequence which encompasses metacognition, critical reasoning and communication, and reflection. Under the selected content and the context, the three components in Figure 3 are well connected. Proficiency of skills and procedures is also developed through content and context in appropriate situations and necessary exercise.

8 The delegates from SEAMEO Member Countries worked together at the SEAMEO RECSAM-University of Tsukuba Joint Seminar: Searching for Quality Mathematics Curriculum Framework on the Era of Globalization, February 15-18, 2016 (The University of Tsukuba is an affiliated member of SEAMEO) for the establishment of agreement on the format of curriculum. In the meeting, 21st century curriculum frame work and every countries frame work were presented. The four content strands and one process-humanity strand for every learning stage were agreed. The hierarchy under content strands is also deduced as follows: every content strand, topic is described in a sentence beginning from a verb in a gerund form to embed context into content, every topic standard is described in sentences with a verb and adjective to emphasize the activity and value.

Sample Format

SEA-BES CCRLS Mathematics is developed under the Framework in Figure 3 and for the 21st century skills and choses the following format to distinguish and relate the descriptions of standards beyond the stages. On this format, every standard embeds the ideas for what are expected to be learned, how it is related with other standards and why it is necessary for further learning.

Key Stage Number

General explanation for every stage.

Strand: Title of Strand under the Stage

The description of each strand gives clear images for the developmental level in three Key Stages.

Topics:

A set of Content standards is described under the topic. Every topic sentence begins from the gerund form of the verb that implies mathematical process-humanity. In the case of Mathematical Process-Humanity Strand in every stage, every standard is described under the strand without categorizing into the topics.

Standard:

Every standard is described with gerund form and verb to show process and adjective to cite value and attitude as follows:

(Sample) Enjoying counting orally and manipulatively with number names, without symbolic numerals

i. Develop the fluency of the order of number names and use it based on the situation
ii. Set initial object for counting, direction of counting and recognize the end of objects with one to one correspondence

Chapter 2

Key Stage 1

Key Stage 1 (KS1) serves as the foundation of knowledge covering the basic facts and skills developed through simple hands-on activities, manipulation of concrete objects, pictorial and symbolic representations. This stage focuses on arousing interest, enjoyment and curiosity in the subject through exploration of pattern, characterization, identification and describing shapes, performing the four fundamental operations, identify its algorithm, and understanding basic mathematical concept and skills experienced in daily life. Calculation of quantities will also be established to carefully and wilfully understand the attribution of objects that are used to make direct and indirect comparison.

Strand: Numbers and Operations

Number is introduced with situations, concrete objects, pictorial and symbolic representations and extended based on knowledge and skills learned. Ways of counting and distributions are extended to addition, subtraction, multiplication and division. Base ten number system is the key for extending the numbers and operations for standard algorithms in vertical form. Also, various procedures of calculations and algorithms are focused. Models and diagrams are used for extension instead of concrete materials itself. Number sense will be developed through the establishment of fluency of calculations with connection to situations and models. Fractions and decimals are introduced with manipulative.

Topics:

Introducing numbers up to 120

Introducing addition

Introducing subtraction

Utilizing addition and subtraction

Extending numbers with base ten system up to 1 000 000 gradually

Producing the vertical forms for addition and subtraction and acquiring fluency of standard algorithms

Introducing multiplication and producing multiplication algorithm

Introducing division and extending it to remainder

Introducing fractions and extending to addition and subtraction of similar fractions

Introducing decimals and extending to addition and subtraction

Introducing numbers up to 120

Enjoying counting orally and manipulatively with number names, without symbolic numerals;

i. Develop the fluency of the order of number names and use it based on situations[9]

ii. Set initial object for counting, direction of counting and recognize the end of objects with one to one correspondence

Understanding and using the cardinality and ordinality of number with objects and numerals[10] through activities of grouping, corresponding and ordering, and developing number sense[11]:

i. Group objects for counting with conditions such as cups, flowers, and rabbits on situations and introduce the numerals

ii. Obtain fluency of counting concrete objects and understand counting on

iii. Compare different sets by one to one correspondence and recognize larger, smaller or equal with appreciation in drawing paths between objects

iv. Compose and decompose numbers for strengthening the number sense[12] and cardinality

v. Understand the difference of ordinal and cardinal numbers and use them appropriately in situations and challenge the mixed sequence

vi. Acquire number sense[13] in ordering numerals with and without concrete objects

Introducing base ten system with groupings of 10 and extend numbers up to 120[14].

i. Extend numbers to more than 10 with base ten manipulative representing numbers in ones and tens, and appreciate base ten numeration system

ii. Extend the order sequence of numbers to more than 10 in relation to the size of ones and tens and compare numbers using numeral in every place

iii. Introduce number lines to represent the order of numbers starting from zero to see it from counting by ones, twos, fives, and tens, and use it as comparison

9 The denomination such as 3 cups, 2 cups, one cup is described at the Quantity and Measurement strand.
10 Inclusive in reading and writing of numerals.
11 Unit for counting that is described in the Quantity and Measurement strand.
12 Relationship of composing and decomposing numbers becomes the preparation for addition and subtraction for inverse operation.
13 Number pattern is discussed under Pattern and Data Representations.
14 For discussing the difference of hundred twenty is not twelve ten in English.

iv. Enjoy various ways of distribution of objects with counting such as playing cards, and explain it and enhance number sense

v. Draw diagram for representing the size of number with base ten blocks such as square for a unit of hundred and rectangular bar for a unit of ten

Introducing Addition

Understanding the situations for addition up to 10 and obtaining fluency using addition in situations

i. Introduce situations (together, combine, and increase) for addition and explain it with manipulative and orally to define addition for operation

ii. Develop fluency of addition expressions using composition of numbers for easier calculation using number sense for composition of numbers

iii. Apply addition with fluency in life

Extending addition to more than 10 and obtaining fluency using addition in situations

i. Extend addition with situations and think about how to answer using the idea of making 10 with decomposition and composition of numbers

ii. Explain the idea of addition with place value using block diagrams

iii. Develop fluency of addition expressions to more than 10 for easier calculation

iv. Apply addition fluency in life

Introducing Subtraction

Understanding situations for subtraction up to 10 and obtaining fluency using subtraction in situations

i. Introduce situations (remaining, decrease, and difference) for subtraction and explain it with manipulative and orally to and define subtraction for operation[15]

ii. Develop fluency of subtraction expressions using decomposition of numbers for easier calculation

iii. Apply subtraction fluency in life

15 Distinguish minuend and subtrahend.

Extending subtraction to more than 10 and obtaining fluency using subtraction in situations

i. Extend subtraction with the situations and think about how to answer using the idea of 10 with addition and subtraction of numbers
ii. Explain the idea of subtraction in place value using block diagram
iii. Develop fluency of subtraction expressions to more than 10 for easier calculation
iv. Apply subtraction fluency in daily life

Utilizing Addition and Subtraction

Utilizing addition and subtraction in various situations and understanding their relationships

i. Understand the difference of addition and subtraction with diagrams on situations
ii. Explain subtraction as an inverse of addition on situations with diagrams
iii. Understand addition with three numbers, subtraction with three numbers and combination of addition and subtraction on situations
iv. Apply addition and subtraction in various situations such as ordering numbers

Extending Numbers with Base Ten System Up To 1 000 000 Gradually

Extending numbers using base ten system up to 1 000

i. Experience counting of 1 000 by using various units and appreciate the necessity of the base ten system
ii. Extend the order of numbers to more than 1 000 in relation to the size of ones, tens and hundreds
iii. Use number line partially to compare size of numbers through translation of the size of every digit and select appropriate scale
iv. Represent appropriate diagram to show the size of numbers without counting such as three of hundreds mean 30 of tens and visualize the relative size of numbers
v. Represent larger or smaller numbers by symbol of inequality

Extending numbers using base ten system up to 10 000

i. Visualize the 10 000 by using thousand, hundred, ten and one as unit

ii. Extend the order sequence of numbers to more than 10 000 in relation to the size of ones, tens , hundreds and thousands

iii. Use number line with appropriate scale to show size of numbers and to show relative size of numbers while focusing on the scale

Extending numbers using based ten system up to 1 000 000[16]

i. Extend numbers up to 10 000 and learn the representation of the place value for grouping every 3-digit numeral system up to million

ii. Write large numbers using grouping of 3-digit numeral system[17] such as thousand as a unit and compare numbers in relation to it

iii. Develop number sense such as larger and smaller based on comparison of place values through visualization of relative size of numbers

Producing the vertical forms for addition and subtraction[18] and acquiring fluency of standard algorithms

Thinking about the easier ways for addition and subtraction and producing vertical form with algorithms

i. Think about easier ways of addition or subtraction in situations and use models with base ten blocks meaningfully for representing base ten system

ii. Produce and elaborate efficient ways and identify the standard algorithms[19] in relation to base ten system with appreciation

iii. Explain the algorithms of borrowing and carrying with regrouping of base ten models

iv. Acquire fluency in addition and subtraction algorithms

16 One million is too big for counting and is introduced only for learning of the three digit system.

17 3-digit numeral system such as 123 times thousand equals the same way of reading plus thousand. In the case of Chinese, four- digit numeral system is used.

18 Understanding the relationship of addition and subtraction is discussed under Pattern and Data Representations.

19 Various algorithms are possible and there is no one specific form because depending on the country, vertical form itself is not the same. Here, standard algorithm means the selected appropriate form.

Acquiring fluency of standard algorithm for addition and subtraction and extend it up to 4 digit numbers

i. Extend the vertical form addition and subtraction through the extension of numbers and appreciate the explanation using block model

ii. Develop fluency of every extension up to 3-digit numbers and simple case for 4 digit numbers

Developing number sense[20] for estimation[21] and using calculator sensibly for addition and subtraction

i. Develop number sense for mental arithmetic with estimation for addition or subtraction of numbers

ii. Identify necessary situation to use calculators sensibly in real life

iii. Appreciate the use of calculator in the case of large numbers for finding total and balance

Introducing Multiplication and Producing Multiplication Algorithm

Introducing multiplication and mastering multiplication table

i. Understand the meaning of multiplication[22] in situations with models using the idea of addition and distinguish from just addition to find the amount that is a number of the base amount

ii. Produce multiplication table in the case of counting by 2 and 5 with array diagrams, pictures or block models and extend it until 9 and 1 with appreciation of patterns[23]

iii. Develop sense for multiplication through mental calculation with fluency

iv. Use multiplication in daily life, differentiating the situations for multiplication in various situations with understanding that any number can be a unit for counting in multiplication

Producing multiplication in vertical form and obtaining fluency

i. Think about easier ways of multiplication in the case of numbers greater than 10 using array diagrams and block models

ii. Develop multiplication in vertical form using multiplication table, array, model, and base ten system with appreciation

20 *Money system is discussed under Measurement and Relations.*
21 *Rounding numbers are treated in Key Stage 2 under Measurement and Relations.*
22 *Meaning of area is described in Measurement and Relations.*
23 *Multiplication row of 1 is not a repeated addition.*

iii. Extend multiplication algorithm to 3- digits times 2-digits number

iv. Obtain fluency for standard algorithm for multiplication

v. Use estimation with multiplication of tens or hundreds in life

vi. Compare the multiplication expressions which is larger, smaller or equivalent

vii. Appreciate the use of calculator sensibly in life in the case of large numbers

Introducing Division and Extending It to Remainder

Introducing division with two different situations and find the answer by multiplication

i. Understand division with quotative and partitive division for distribution situations

ii. Think about how to find the answer of division situations by the distributions using diagrams, repeated subtractions and multiplication

iii. Obtain fluency to identify answers of division through inverse operation of multiplication

iv. Appreciate the use of multiplication table for acquiring mental division

Extending division into the case of remainders and use division for distribution in daily situations

i. Extend division in situations with remainders and understand division even it has the same as repeated subtraction with different remainders

ii. Obtain fluency for division and apply it in daily situations

iii. Understand division algorithm in simple case

Introducing Fractions and Extending to Addition and Subtraction of Similar Fractions

Introducing simple fractions such as halves, quarters and so on based on the number of halves, quarters and so on using paper folding and drawing the diagram

i. Introduce simple fractions using manipulative such as paper folding and drawing diagram on the context of part whole relationship

ii. Use "*a half of*" and "*a quarter of*" in the daily context such as half a slice of bread

iii. Count a quarter for representing one quarter, two quarters, three quarters, and so on

iv. Compare simple fractions in the case where the whole is the same and explain

Extending fractions using tape diagram and number line to one, and think about how to add or subtract with similar fractions for producing simple algorithm

i. Extend fractions to more than one unit quantity for representing the remaining parts such as measuring the length of tape, recognizing the remaining parts as a unit measure of length, and understand proper and improper fractions

ii. Appreciate fractions with quantities in two ways; firstly, whole is a unit of quantity and secondly, based on the number of unit fraction

iii. Compare fractions in the case where the whole is the same and explain it with tape diagram or number line, and develop number sense of fractions such as 1/10 with quantities and so on

iv. Think about how to add or subtract similar fractions with tape diagram or number line and produce simple algorithm with fluency

Introducing decimals and extending to addition and subtraction

Introducing decimals to tenths, and extend addition and subtraction into decimals

i. Introduce simple decimals to tenths by remaining part such as tape diagram with appreciation

ii. Compare size of decimal numbers on the number line with the idea of place value

iii. Extend addition and subtraction of decimals with utilizing the place value system in vertical form until up to tenths

iv. Think about appropriate place value for applying addition and subtraction in life

Strand: Quantity and Measurement

Attributes of objects are used to make direct and in-direct comparison. For comparison, the non-standard and standard units are used. Counting activities denominate units of quantities such as cups for volumes, arm-length and hand-spans for length. Standard units such as meter, centimeter, kilogram and liter are introduced. Time and durations which are not base ten system are introduced. Money is not a complete model for base 10 system. The concept of conservation of quantities will be established through the calculation of the quantities. The sense for quantity is developed through the appropriate selection of measurement tools.

Topics:

Comparing sizes directly and indirectly using appropriate attributes and non-standard units

Introducing quantity of length and expanding it to distance

Introducing quantity of mass for its measurement and operation

Introducing quantity of liquid capacity for its measurement and operation

Introducing time and duration and its operation

Introducing money as quantity

Comparing Size Directly and Indirectly Using Appropriate Attributes and Non-Standard Units

Comparing and describing quantity using appropriate expression

i. Compare two objects directly by attributes instead of stating in length and amount of water such as longer or shorter and less or more

ii. Compare two objects indirectly using non-standard units to appreciate the unification of units

iii. Use appropriate denomination[24] of quantity (such as number of cups) for counting and appreciate the usage of units for quantity for suitable context

24 Denomination is necessary for learning the group of counting. It is also described in the strands of Pattern and Data Representations and Numbers and Operations both of Key Stage 1.

Introducing quantity of length and expanding it to distance

Introducing centimeter for length and extend to millimeter and meter

i. Compare length of different objects and introduce centimeter with calibrated tape[25] of one centimeter

ii. Demonstrate equivalent length with addition and subtraction such as part-part whole

iii. Extend centimeter to millimeter to represent remaining parts with ideas of equally dividing and idea of making tens

iv. Extend centimeter to meter to measure using meter stick

v. Estimate length of objects and select appropriate tools or measuring unit for measurement with fluency

vi. Convert mixed and common units of length for comparison[26]

vii. Convert mixed and common units of length when adding or subtracting in acquiring the sense for quantity

Introducing distance for the extension of length

i. Introduce kilometer to measure distance travel using various tools and appreciate the experiences of measuring skills

ii. Distinguish distance travel and the distance of two places on the map

iii. Compare mixed units of length with appropriate scale on number line

Introducing Quantity of Mass for Its Measurement and Operation

Introducing gram for mass and extend to kilogram and tons

i. Compare mass of different objects directly using balance and introduce gram

ii. Demonstrate equivalent mass with addition and subtraction such as part-part whole

iii. Extend gram to kilogram, measure with weighing scale

iv. Extend kilogram to metric ton through relative measure (such as 25 children, each weigh 40 kilogram)

25 The plane tape can be used for direct comparison and indirect comparison by marking. If the tape is scaled by non-standard unit we can use it for measurement. If the tape is scaled by one centimeter we can define the length of centimeter.

26 Which one is longer 2 m, 3 cm or 203 mm?

v. Estimate mass of objects and select appropriate tools or measuring unit for measurement with fluency

vi. Convert mixed and common units of mass for comparison

vii. Convert mixed and common units of mass for addition and subtraction in acquiring the sense for quantity

Introducing Quantity of Liquid[27] Capacity for Its Measurement and Operation

Introducing liter for capacity of liquid and extend to milliliter

i. Compare amount of water in different containers and introduce liter with measuring cups of 1 liter

ii. Demonstrate equivalent capacity with addition and subtraction such as part-part whole

iii. Extend liter by deciliter/100 millilitre cup for representing remaining parts with ideas of equally dividing and making 10, and extend until milliliter

iv. Estimate capacity of containers and select appropriate measuring unit

v. Convert mixed and common units of capacity for comparison

vi. Convert mixed and common units of capacity for addition and subtraction in acquiring the sense for quantity

Introducing Time and Duration, and Its Operation

Introducing analog time and extend it to duration

i. Tell and write analog time of the day corresponding with different activities in daily life such as morning, noon, afternoon, day and night

ii. Show time by using clock face with hour hand and minute hand

iii. Understand the relative movement of clock hands

Extending clock time to duration of one day[28]

i. Introduce duration in hours and minutes based on beginning time and end time of activities

27 The density which explains the relationship between mass and liquid capacity is usually learned in Science at later stage. In the case of CCRLS Science it starts in Key Stage 2 such as 1 cubic centimeter of water is equivalent to 1 gram.

28 Calendar is possible in the Key Stage 1 under Pattern and Data Representations.

ii. Express time and duration on time line, and understand duration as difference of two distinguished times

iii. Addition and subtraction of duration and time

iv. Extend time and duration to seconds

v. Convert mixed and common units of duration for comparison

vi. Estimate duration of time and select appropriate measuring unit for measurement with fluency and appreciate the significance of time and duration in life

vii. Appreciate the difference in time depending on the area (time zone) and the seasons

Introducing Money as Quantity

Introducing money as quantity and use it as the model of base ten system[29]

i. Introduce unit of money using notes and coins and determine the correct amount of money

ii. Use counting by fives and so on for base ten system

iii. Appreciate the fluency for calculation of money with all the four operations

iv. Appreciate number sense for conversion and transaction of money in life

Strand: Shapes, Figures and Solids

Basic skills of exploring, identifying, characterizing and describing shapes, figures and solids are learned based on their features. Activities such as paper folding enable exploration of various features of shapes. Identification of similarities and differences about shapes and solids enable classification to be done for defining figures. Using appropriate materials and tools, relationship in drawing, building and comparing the 2D shapes and 3D objects are considered. Through these activities, the skills for using the knowledge of figures and solids will be developed. The compass is introduced to draw circles and scale with the same length.

Topics:

Exploring shapes of objects

Characterizing the shapes for figures and solids

Explaining positions and directions

29 Coins and notes are depending on the country. Some country use currency unit of twenty and twenty-five which are in coins or notes. These forms are not appropriate for the model of base 10 system.

Exploring Shapes of Objects

Exploring shapes of objects for finding their attributes

i. Roll, fold, stack, arrange, trace, cut, draw, and trail objects (blocks such as boxes, cans and so on) for knowing their attributes

ii. Use attributes of blocks for drawing the picture by tracing the shape on the paper and explain how to draw it with the shape

iii. Create patterns of shapes (trees, rockets and so on) by using the attributes and recognize the characteristics of shapes[30]

iv. Appreciate the functions of shapes of objects in life

Characterizing the Shapes for Figures and Solids

Describing figures with characters of shapes

i. Use characters of shapes for understanding figures (quadrilaterals, square, rectangle and triangle, right angle, same length)

ii. Introduce line and right angle with relations to activities such as paper folding and use it for describing figures with simple properties such as triangle has 3 lines

iii. Appreciate the names of figures in daily life by using mother-tongue such as "segi tiga" and "segi empat" in Malay and "*tatsulok*" in Tagalog

iv. Classify triangles by specific properties, such as sides, angles and vertex (right triangle, equilateral, isosceles)

Describing solids with characters of shapes

i. Use the characters of shapes, understanding solids such as boxes can be developed by six rectangular parts with simple properties

ii. Develop boxes with the properties

iii. Appreciate the solids around daily life through considering the function of the solids

Drawing circle and recognizing sphere based on circle

i. Think about how to draw a circle and find the center and radius

ii. Draw a circle with an instrument such as compass

iii. Enjoy drawing pictures using the function of circles such as Spirograph

30 Pattern of shapes is discussed in Key Stage 1 under Pattern and Data Representations.

iv. Find the largest circle through cutting the sphere and recognize the sphere by the center and radius

v. Appreciate function of circles and spheres in daily life such as the difference between soccer ball and rugby ball

Explaining Positions and Directions

Exploring how to explain the position and direction

i. Identify simple positions and directions of an object accurately using various ways such as in my perspective, in your perspective in the classroom, and the left, right, front, back, west, east, north, south and with measurement

ii. Draw the map around the classroom with consideration of the location

iii. Design a game to appreciate the changing of positions and directions in a classroom

Strand: Pattern and Data Representations

Various types of patterns are treated such as the number sequences and repetitions of shapes. Size of pictures can be represented by the number sequences. Tessellation of shapes and paper folding can be represented by the repetition of shapes. Exploration of patterns and features are also considered to represent the data structure in our life with pictographs and bar graphs. Patterns and features produce meaning of data and represent mathematical information. Patterns are represented by diagrams and mathematical sentences which are also used for communication in identifying and classifying situations to produce meaningful interpretations.

Topics:

Using patterns under the number sequence

Producing harmony of shapes using patterns

Collecting data and representing the structure

Using Patterns under the Number Sequence[31]

Arranging objects for beautiful pattern under the number sequence

i. Know the beautifulness of patterns in cases of arranging the objects depending on number sequence

ii. Arrange objects according to number sequence to find simple patterns

31 Number sequence will be discussed in Key Stage 1 under Numbers and Operations.

iii. Arrange expressions such as addition and subtraction to find simple patterns

iv. Express the representation of patterns using placeholders (empty box)

v. Enjoy the arrangement depending on number sequence in daily life

vi. Find patterns on the number table such as in calendars[32]

Producing harmony of shapes using patterns[33]

Arranging tiles of different or similar shapes in creating harmony

i. Know the beautifulness of patterns in cases of arranging the objects depending on shapes, colours and sizes

ii. Arrange objects according to shapes, colours and sizes to show patterns

iii. Arrange boxes according to shapes, colours and sizes to create structure

iv. Arrange circles and spheres for designing

v. Enjoy the creation depending on different shapes, colours and sizes in daily life

Collecting data and representing the structure

Counting data through categorization for getting information

i. Explore the purpose of why data is being collected

ii. Group the data in creating similar attributes on the denomination[34] of categories and count them (check mark and count)

iii. Think about what information is obtained from the tables with categories and how to use it

Organizing the data collected and represent using pictogram for easy visualization

i. Produce the table and pictograms from collected data under each categories

ii. Interpret tables and pictograms as a simple conclusion about the data being presented

iii. Appreciate pictograms through collecting data and adding data in daily activities in life

32 Time and duration are discussed in key stage 1 under Quantity and Measurement.

33 Harmony of shapes will be discussed in Key Stage 1 under Shapes, Figures and Solids.

34 Denomination will be learned in Key stage 1 under Quantity and Measurement.

Representing a data structure by using bar graph to predict the future of communities

i. Understand how to draw bar graph from table using data categories and sort the graph for showing its structure

ii. Appreciate ways of presenting data such as using tables, pictograms and bar graphs with sorting for predicting future communities

iii. Appreciate the use of data for making decision

Strand: Mathematical Process - Humanity

Enjoyable mathematical activities are designed to bridge the standards in different strands. Exploration of various number sequence, skip counting, addition and subtraction operations help to develop number sense that is essential to support explanation of contextual scenarios and mathematical ideas. Mathematical ways of posing questions in daily life are also necessary learned at this stage. Ability to select simple, general and reasonable ideas enables effective future learning. Application of number sense provides facility for preparing sustainable life. The use of ICT tools and other technological tools provide convenience in daily life. At initial stage, concrete model manipulation is enjoyable, however drawing diagram is most necessary for explaining complicated situations by using simple representation.

Standards

Enjoying problem solving through various questioning for four operations in situations

Enjoying measuring through setting and using the units on various situations

Using blocks as models and its diagram for performing operations in base ten

Enjoying tiling with various shapes and colours

Explaining ideas using various and appropriate representations

Selecting simple, general and reasonable ideas which can apply for future learning

Applying number sense acquired in Key Stage 1 for preparing sustainable life

Utilizing ICT tools such as calculators as well as other tools such as note book and other instrument such as clocks

Promoting creative and global citizenship for sustainable development of neighbourhood using mathematics

Enjoying problem solving through various questioning for four operations in situation[35]

i. In addition, pose questions for altogether and increase in situations
ii. In subtraction, pose questions for remain and difference in situations
iii. In multiplication, pose questions for number of groups in situations
iv. In division, pose questions for partition and quotation in situations
v. Enjoy questioning by using combination of operations in various situations
vi. In operations, pose questions to find the easier ways of calculation
vii. Use posing questions for four operations on measurements in daily life

Enjoying measuring through setting and using the units on various situations[36]

i. Compare directly and indirectly
ii. Set tentative units from difference for measuring
iii. Give appropriate names (denominations) for counting units
iv. Use measurement for communication in daily life
v. Use tables and diagrams for showing the data of measures

Using blocks as models and its diagram for performing operations in base ten[37]

i. Show increasing and decreasing patterns using blocks
ii. Show based ten system using blocks, unit cube is 1, bar stick is 10 and flat block represents 100
iii. Explain addition and subtraction algorithm in vertical form using base ten block model
iv. Explain multiplication table with number of group blocks
v. Explain division using equal distribution of blocks and repeated subtraction of blocks
vi. Use the number of blocks as for measurement in daily life

Enjoying tiling with various shapes and colours[38]

i. Appreciate to produce beautiful designs with various shapes and find the pattern to explain it

35 *It is related with Numbers and Operations and Quantity and Measurement both in Key Stage 1.*
36 *It is related with Quantity and Measurement and Pattern and Data Representations both in Key Stage 1.*
37 *It is related with Pattern and Data Representations and Numbers and Operations both in Key Stage 1.*
38 *It is related with Shapes, Figures and Solids and Pattern and Data Representations both in Key Stage 1.*

ii. Reflect, rotate and translate to produce patterns

iii. Cut and paste various shapes and colours to form the box and ball such as develop the globe from map

Explaining ideas using various and appropriate representations[39]

i. Explain four operations using pictures, diagrams, blocks and expressions for developing ideas

ii. Explain measurement using measuring tools, tape diagrams, container and paper folding for sharing ideas

iii. Make decision on how to explain the figures and the solids by using manipulative objects or diagrams or only verbal explanation

iv. Explain patterns using diagrams, numbers, tables and expressions with blank box

v. Ask questions using terms such as why, how, what, if and if not, and reply using examples and 'for example' in discussion

vi. Change the representation and translate it appropriately in daily life

Selecting simple, general and reasonable ideas which can apply for future learning[40]

i. Discuss the argument for the easier ways for addition and subtraction algorithm in vertical form

ii. Extend the algorithm to large numbers for convenience and fluency

iii. Use the pattern of increase in multiplication table for convenience

iv. Use multiplication tables for finding the answers of division

Applying number sense[41] acquired in Key Stage 1 for preparing sustainable life[42]

i. Use mathematics for the minimum and sequential use of resources in situations

ii. Estimate for efficient use of resources in situations

iii. Maximize the use of resources through appropriate arrangement in space

iv. Understand equally likely of resources in situations

39 It is related to all strands in Key Stage 1.

40 It is related to Numbers and Operations and Pattern and Data Representations both in Key Stage 1.

41 It is related to Numbers and Operations, Pattern and Data Representations and Quantity and Measurement all in included in Key Stage 1.

42 Sustainable development goals were crafted at the 70th Session of the United Nations General Assembly and indicated them as universal value in education.

Utilizing ICT tools such as calculators as well as other tools such as notebook and other instrument such as clocks[43]

i. Use calculators for poly addition in situations

ii. Use mental calculations for estimations

iii. Use balance scale to produce equality and inequality

iv. Use cups, tapes, stop watch, and weighing scale for measuring distances and weights

v. Use calculators to explain the process of calculation by solving backward and understand the relationship of addition and subtraction, and multiplication and division

vi. Enjoy using of notebooks to exchange learning of each other such as mathematics journal writing

vii. Enjoy presentations with board writing

viii. Use various tools for conjecturing and justifying

Promoting creative and global citizenship for sustainable development of neighbourhood using mathematics

i. Utilize the notebooks and journal books to record and find good ideas and share with others

ii. Prepare and present ideas using posters to promote good practices in neighbourhood

iii. Listen to other's ideas and asking questions for better creation

iv. Utilize information, properties and models as basis for reasoning

v. Utilize practical arts and outdoor studies to investigate local issues for improving welfare of life

43 STEM education is enhanced. Mathematics is the major and base subject for STEM Education in Key Stage 1 hence, technological contents are included in Mathematics.

Chapter 3

Key Stage 2

Key Stage 2 (KS2) can be learned based on the Key Stage 1. This stage provides the extension of numbers, measurement and relations, plane figures and solid figures and data handling and graphs. This stage enables to extend four operations to daily use of numbers such as decimal and fraction and allows the use of mathematical terminologies, performing investigations and establish the ground for analyzing, evaluating and creating their life. Appreciating the beauty of the structure of mathematics will enable them to enjoy and sustain their learning which provides basis for Key Stage 3.

Strand: Extension of Numbers and Operations

Numbers are extended to multi-digits, fractions and decimals. Multiplication and division algorithms are completed with fluency. Fraction becomes numbers through the redefinition as a quotient instead of part - whole relationship. Multiplication and division of decimals and fractions are also explored to produce the procedures for calculation. Various representations are used to elaborate and produce meaning for the calculation. Number sense such as approximating numbers, relative size of numbers and values are enhanced for practical reasoning in the appropriate context of life.

Topics:

Extending numbers with base ten up to billion and also to thousandths with three digit numeral system gradually

Making decision of operations on situations with several steps and integrate them in one expression and think about the order of calculations and produce the rule (PEMDAS)

Producing the standard algorithm for vertical form division with whole numbers

Extending the vertical form addition and subtraction with decimals to hundredths

Extending the vertical form multiplication and division with decimals and find the appropriate place value such as product, quotient and remainder

Using multiples and divisors for convenience

Introducing improper and mixed fractions and extending to addition and subtraction of fractions to dissimilar fractions

Extending fractions as numbers and integrate

Extending multiplication and division to fractions

Extending Numbers with Base Ten Up to Billion and Also to Thousandths with Three Digit Numeral System Gradually

Extending numbers using base ten system up to billion[44] with three digit numeral system[45]

i. Adopt the three digit numeral system, extend numbers up to billion with the idea of relative size of numbers

ii. Compare numbers such as larger, smaller with base[46] ten system of place values through visualization of relative size of numbers using cubes, plane, bar and unit

Extending decimal numbers to hundredths, and to thousandths[47]

i. Use the idea of quantity and fractions, extend decimal numbers from tenths to hundredths

ii. Compare decimal numbers such as larger, smaller with base ten system of place value

iii. Adopt the ways of extension up to thousandths and so on, and compare the relative sizes

Making Decision of Operations on Situations with Several Steps and Integrate them in One Expression and Think about the Order of Calculations and Produce the Rule (PEMDAS)

Finding the easier ways of calculations using the idea of various rules of calculations[48] such as the associative, commutative and distributive rule

i. Find the easier ways of addition and subtraction and use it, if necessary, such as answer is the same if add same number to the subtrahend and minuend

ii. Find the easier ways of multiplication and division and use them in convenient ways such as 10 times of multiplicand produce the product 10 times

44 Billion is too large for counting and it is introduced in the three digit system under relative size of number.
45 In British system, it is referred as short scale.
46 Metric system names of units are discussed under Measurement and Relations.
47 Under the three digit system, if we teach until thousandths we can extend by three digits.
48 Use of constant sum, difference, product and quotient is described in Measurement and Relations. (e.g. 25 -21 = 4, 26 – 22 = 4, 27 – 23 = 4)

iii. Use associative, commutative and distributive rules of addition and multiplication for easier ways of calculation, however commutative property does not work in subtraction and division

iv. Appreciate the use of simplifying rules of calculations

Thinking about the order of calculations in situations and produce rules and order of operations

i. Integrate several steps of calculation into one mathematical sentence

ii. Produce the rule of PEMDAS and apply it to the several steps situation

iii. Think about the easier order of calculation and acquiring fluency of PEMDAS and rules with appreciation

Producing the Standard Algorithm for Vertical Form Division with Whole Numbers

Knowing the properties of division and use it for easier way of calculation

i. Find the easier ways of division and use it, if necessary, such as answer is the same if multiplying the same number to the dividend and divisor

ii. For confirmation of answer of division, use the relationship among divisor, quotient and remainder and appreciate the relationship

Knowing the algorithm of division in vertical form and acquiring fluency

i. Know the division algorithm with tentative quotient and confirm the algorithm by the relationship among divisor, quotient and remainder

ii. Interpret meaning of quotient and remainder in situations

iii. Acquire fluency for division algorithm in the case of up to 3-digit whole number divided by 2-digit

iv. Think about the situations with or without remainder in relation to situations for quotative and partitive division

Extending the Vertical Form Addition and Subtraction with Decimals to Hundredths

Extending the vertical form addition and subtraction in decimals to hundredths

i. Extend the vertical form addition and subtraction to hundredths[49] place and explain it with models

ii. Appreciate the use of addition and subtraction of decimals in life

49 Discussion of decimals to hundredths is related to the use of money. It is a minimum requirement. If teaching to hundredths, further extension of place value can be understood.

Extending the Vertical Form Multiplication and Division with Decimals and Find the Appropriate Place Value such as Product, Quotient and Remainder

Extending the multiplication from the whole number to decimal numbers

i. Extend the meaning of multiplication with the idea of measurement by the number of unit length for multiplication of decimal numbers and use diagrams such as number lines to explain them with appreciation in situations

ii. Extend the vertical forms multiplication of decimals up to 3 digits by 2 digits with consideration of the decimal places step by step

iii. Obtain fluency using multiplication of decimals with sensible use of calculators in life

iv. Develop number sense in multiplication of decimals[50] such as comparing sizes of products before multiplying

Extending the division from the whole number to decimal numbers

i. Understand how to represent division situations using diagrams such as number lines, and extend the diagram of decimal numbers for explaining division by decimal numbers

ii. Extend the division algorithm in vertical form of decimal numbers and interpret the meaning of decimal places of quotient and remainder with situations

iii. Acquire fluency in division algorithm of decimals up to 3 digits by 2 digits with consideration of decimal places step by step

iv. Obtain fluency using division of decimals with sensible use of calculators in life

v. Develop number sense of division in decimals such as comparing sizes of quotient before multiplying

vi. Distinguish the situations with decimal numbers of multiplication and division

50 Applying the idea of multiplication into ratio, percent and proportion is discussed in Measurement and Relations.

Using Multiples and Divisors for Convenience

Using multiples and divisors for convenience with appreciation to enrich number sense

i. Understand set of numbers by using multiple and divisor

ii. Find common multiple and appreciate the use in situations, and enrich number sense with figural representations such as arrangement of rectangles to produce a square

iii. Find common divisor and appreciate its use in situations, and enrich number sense with figural representations such as dividing a rectangle into pieces of square

iv. Understand numbers as composite of multiplication of numbers as factors[51]

v. Appreciate ideas of prime, even and odd numbers in situations using multiples and divisors

vi. Acquire the sense of number to see its multiple for convenience

Introducing Improper and Mixed Fractions and Extending to Addition and Subtraction of Fractions to Dissimilar Fractions

Extending fractions to improper, mixed and equivalent fractions

i. Extend fractions to improper and mixed fractions using number line of more than one by measuring with unit fraction[52]

ii. Find ways of determine equivalent fractions with number lines and with the idea of multiple of numerator and denominator

iii. Compare fractions using number line and the idea of multiple

Extending addition and subtraction of similar fractions to improper and mixed fractions, and dissimilar fractions

i. Extend addition and subtraction of similar fractions to proper and mixed fractions with explanations using models and diagrams

ii. Extend addition and subtraction into dissimilar fractions with explanations using diagrams and common divisors

iii. Acquire fluency of addition and subtraction of fractions with appreciation of idea to produce the same denominators

51 This idea is related to the strand on Measurement and Relations in Key Stage 2 under the area of rectangle.
52 Extension of fraction more than one is done by using the fraction with quantity for situation such as $\frac{4}{3}m$.

Extending Fractions as Numbers and Integrate[53]

Seeing fractions[54] as decimals and seeing decimals as fractions

i. See fractions as decimals using division and define quotient from the case of indivisible

ii. See decimals as fractions such as hundredths is per hundred

iii. Compare decimals and fractions and ordering them on the number line

Extending Multiplication and Division to Fractions

Extending multiplication to fraction

i. Extend the multiplication to fraction with situations using diagrams such as number lines, step by step, and find the simple algorithm for the multiplication of fractions

ii. Acquire fluency with multiplication of fractions

iii. Develop number sense[55] of multiplication of fractions such as comparing sizes of products before multiplying

Extending division to fraction

i. Extend the division to fraction with situations using diagrams such as number lines, step by step

ii. Acquire fluency with division of fractions

iii. Develop number sense of division of fractions such as comparing sizes of quotients before dividing

53 Selecting the appropriate denomination of quantities and units for fraction in the context ($\frac{2}{3}m$ is two of $\frac{1}{3}m$ and the whole is 1m, however $\frac{3}{3}m$ is $3x(\frac{1}{3})m$; the structure is the same as tens is ten of units and discussed under Measurement and Relations.

54 Fraction as ratio is introduced in Measurement and Relations.

55 Applying the idea of the multiplication of fraction into ratio, proportion, percentage and base is discussed in Measurement and Relations.

Strand: Measurement and Relations

Additive quantity such as angles, areas and volume and relational quantities such as population density, and speed are introduced. Additive quantity can be introduced by establishment of the standard unit which is the same way as the Quantity and Measurement of Key Stage 1. Relations of quantities in situations are discussed with patterns such as sum is constant, difference is constant, product is constant and quotient is constant using tables and represented by mathematical sentences and letters. Proportion and ratio are introduced with representations of diagrams, graphs and tables for multiplication, and connected with decimals and fractions. Percent is introduced with diagrams in relation to ratio and proportion. Relational quantity is produced by different quantities with understanding of ratio. Area of a circle is discussed through a proportional relationship between radius and the circumference. Ideas of ratio and proportion are fluently applied for real world problem solving.

Topics:

Introducing angle and measuring it

Exploring and utilizing constant relation

Extending measurement of area in relation to perimeter

Extending measurement of volume in relation to surface

Approximating with quantities

Extending proportional reasoning to ratio and proportion

Producing new quantities per unit

Investigating the area of a circle

Exchanging local currency with currency in ASEAN community

Extending the relation of time and use of calendar in life

Converting quantities in various system of units

Showing relationship using Venn diagram

Introducing Angle and Measuring It[56]

Introducing angle by rotation, enabling measuring and acquire fluency using the protractor

i. Compare extent of rotation and introduce degree as a unit for measuring angle

ii. Recognize right angle is 90 degrees, and adjacent angle of two right angles is 180 degrees, and 4 right angles is 360 degrees

iii. Acquire fluency in measuring angles using the protractor

iv. Draw equivalent angles with addition and subtraction using multiples of 90 degrees

v. Appreciate measurement of angles in geometrical shapes and situations in life[57]

Exploring and Utilizing Constant Relation

Exploring equal constant relation with utilization of letters to represent placeholders[58]

i. Explore two possible unknown numbers such that their sum (or difference/ product/quotient) is constant[59], for example □+Δ=12 (□ and Δ are placeholders)

ii. Use letters instead of placeholder[60] (empty box) to derive equivalent relation

iii. Understand the laws for operations (e.g. associative, commutative and distributive, etc.) to explain the simpler way of calculation

iv. Appreciate the use of diagrams such as number lines and area to represent relation when finding solutions

Extending Measurement of Area in Relation to Perimeter

Introducing area and produce formula for the area of rectangle

i. Compare extent of area and introduce its unit, and distinguish it from perimeter

ii. Introduce one square centimeter as unit for area and its operation using addition and subtraction

56 Right angles are learned at Key Stage 1 in Shapes, Figures and Solids for explaining the properties of figures.
57 Conservation of angles will be re-learnt in triangle under Key Stage 2 Plane Figures and Space Solids.
58 The idea for the use of Numbers and Operations (Key Stage 2) in finding the easier ways of calculations with the idea of rules of calculations.
59 Constants of multiplication and division correspond to proportionality in multiplication table at Key Stage 1 under Numbers and Operations. Constants of addition and subtraction are treated in Key Stage 1 under Pattern and Data Representations.
60 Place folders are introduced in Key Stage 1.

iii. Investigate area of rectangles and squares and produce the formula of area[61]

iv. Extend square centimeter to square meter and to square kilometer for measure of large areas

v. Convert units and use appropriate units of area with fluency

vi. Draw the equivalent size of rectangular area based on a given area with the composite numbers[62]

vii. Appreciate the use of areas in daily life such as comparing of land sizes

Extending area of rectangle to other figures to derive formula

i. Explore and derive formula for the area of parallelogram by changing its shape to rectangle without changing its area

ii. Explore and derive formula for the area of triangle by bisecting a rectangle into two triangles without changing its area

iii. Appreciate the idea of changing or dividing shapes of rectangle, parallelogram, or/and triangle for deriving the area of other figures

iv. Use the formulas to calculate areas in daily life

Extending Measurement of Volume in Relation to Surface

Introducing volume from area and derive formula for cuboid

i. Compare extent of volume and introduce its unit, and distinguish it from surface

ii. Introduce one cubic centimeter as unit for volume and its addition and subtraction

iii. Investigate volume of cuboid and cube and produce the formulas

iv. Extend cubic centimeter to cubic meter to measure large volume

v. Convert units and use appropriate units of volume with fluency

vi. Appreciate the use of volume in life such as comparison of capacity of containers

Extending volume of cuboid to other solid figures to derive formula

i. Extend the formula for the volume of cuboid as base area x height for exploring solid figures such as prism and cylinder

61 Multiplications are studied in Key Stage 1 Number and Operations.

62 The idea of composite numbers such as 2 times 10 equals 5 times 4 is related to the factors in extending the numbers and operations at Key Stage 2.

ii. Extend the formula for the volume of prism and cylinder to explore and derive the volume formula of pyramid and cone

iii. Use the formulas to calculate volume in daily life

Approximating with Quantities

Approximating numbers with quantities depending on necessity of contexts

i. Understand the ways of rounding such as round off, round up and round down

ii. Use rounding as approximation for making decision on the quantity with related context

iii. Critique over approximation beyond the context with a sense of quantity such as based on relative size of unit

Extending Proportional Reasoning to Ratio[63] and Proportion

Extending proportional reasoning to ratio and percent

i. Understand ratio as relationship between two same quantities or between two different quantities (the later idea is rate)[64]

ii. Express the value of ratio by quotient such as rate of two different quantities[65]

iii. Understand percent as the value of ratio with same quantity[66]

iv. Understand proportion with ratio

v. Apply the rule of three[67] in using ratio

Extending proportional reasoning to proportion

i. Extend proportional reasoning on multiplication tables as equal ratio and understand proportions

ii. Understand proportion by multiple and constant quotient, not changing the value of ratio[68]

63 Band graph and pie chart for representing ratio are discussed under Key Stage 2 on the strand Data Handling and Graphs.

64 Ratio of different quantity is rate. Ratio of the same quantity is a narrow meaning of ratio.

65 The value of fraction as ratio is not necessary a part of whole in situations. Fraction as ratio is usually used on the context of multiplication in situation, where denominator is the base or unit for comparison.

66 Percent is used in Data Handling and Graphs.

67 Rule of three is the method on the table to find one unknown term from the three known terms using proportional reasoning such as;

a	*c*
?	*d*

68 Enlargement is discussed in Key stage 2 under Plane Figures and Space Solids. The graph is treated at Key Stage 2 under Data Handling and Graphs strand.

iii. Demonstrate simple inverse proportion by constant product[69]

iv. Express proportion in mathematical sentence by letters and graph[70]

v. Use properties of proportionality to predict and explain phenomenon in daily life

Producing New Quantities by Per Unit

Producing new quantities by per unit with the idea of average such as population density and speed

i. Introduce average as units for distribution and comparison of different sets of values

ii. Introduce population density with the idea of average and appreciate it for comparison

iii. Introduce speed with the idea of average and appreciate it for comparison

iv. Appreciate using diagrams such as number lines and tables to decide the operations on the situations of measurement per unit quantity

v. Compare on the context of different quantities with the idea of average as rate[71]

vi. Apply the idea of measurement per unit quantity in different context[72]

Investigating the Area of Circle

Areas of a circle are discussed through relationship between radius and the circumference

i. Investigate relationship between the diameter of circle and its circumference using the idea of proportion

ii. Investigate area of a circle by transforming into triangle or parallelogram and find the formula of circle

iii. Estimate the area of inscribed and outscribed shapes based on known formula of area[73]

iv. Enjoy to estimate the area of irregular shapes with fluency in life

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69 Proportion and Inverse proportion are necessary in Key Stage 3 in Science.

70 This will be discussed in detail in Key Stage 2 under Data Handling and Graphs.

71 On Numbers and Operations in Key Stage 2, rate is the value of division as quotient.

72 Using measurement per unit quantity with fluency to make logical judgment in daily life, refer to Key Stage 2 Data Handling and Graphs.

73 Relationships on polygons and circles are discussed in Key Stage 2 under Plane Figures and Solids.

Exchanging Local Currency with Currency in ASEAN Community

Exchanging local currency in ASEAN community with the idea of rate

i. Extend the use of ratio for currency exchange (rate of exchange)
ii. Apply the four operations for money in appropriate notation in life
iii. Appreciate value of money

Extending the Relation of Time and Use of Calendar in Life

Extending the relation of time and use of calendar in life

i. Convert time in 12-hour system with abbreviation a.m. and p.m. to 24-hour system and vice versa
ii. Investigate the numbers in calendar to relate days, weeks, months and year using the idea of number patterns
iii. Appreciate the significance of various calendars in life

Converting Quantities in Various System of Units

Converting measurement quantities on international and non-international system with idea of base 10

i. Convert measurement system of meter and kilogram with prefixes deci-, centi-, and milli-, and with deca-, hecto-, and kilo-
ii. Convert measurement system of liter with cubic centimeter
iii. Convert measurement system of area using acre (a) and hectare (ha) with square meter
iv. Convert measurement of local quantities with standard quantities
v. Understand the unit system with power, such as meter, square meter and cubic meter

Showing Relationship Using Venn Diagram

Using Venn diagram to show relationships of numbers and figures

i. Show relationship of square, rectangles, rhombus, parallelogram, trapezoid and quadrilateral by using Venn diagram
ii. Show relationship of numbers

Strand: Plane Figures and Space Solids

Through tessellation, figures can be extended through plane figures. Parallelogram and perpendicular lines are tools to explain properties of triangles and the quadrilaterals as plane figures. For identifying and recognizing symmetry and congruence parallelogram and perpendicular lines are also needed. Plane figures are used to produce solid in space and vice versa. Opening faces of solids would produce plane figures which are referred as nets. Activities related to building solids from plane figures are emphasized and encouraged to facilitate finding the area of a circle through numerous sectors of the circle to construct a rectangle. Circles are used for explaining the nets of cylinders.

Topics:

Exploring figures with their components in the plane

Exploring solids with their components in relation to the plane

Exploring figures with congruence, symmetry and enlargement

Exploring Figures with Their Components in the Plane

Exploring figures with their components in the plane and use properties

i. Examine parallel lines and perpendicular lines by drawing with instruments

ii. Examine quadrilaterals using parallel and perpendicular lines, and identify parallelogram , rhombus, trapezium by discussion

iii. Find properties of figure through tessellations such as triangle where the sum of the angles is 180 degree, straight angle

iv. Extend figures to polygons, and expand it to circles with knowing and using its properties

Exploring Solids with Their Components in Relation to the Plane

Exploring rectangular prisms and cubes with their components

i. Identify relationship among faces, edges and vertices for drawing sketch

ii. Explore the nets of rectangular prism and find the corresponding position between components

iii. Explore perpendicularity and parallelism between faces of rectangular prism

iv. Explain positions in rectangular prisms with the idea of 3 dimensions

Extending rectangular prism to other solids such as prisms and cylinders

i. Extend the number of relationships among faces, edges and vertices for drawing sketch

ii. Explore nets of prisms and cylinders, and find the corresponding position between components

iii. Distinguish prism and cylinder by the relationship of their faces

Exploring Figures with Congruence, Symmetry and Enlargement

Exploring the properties of congruence

i. Explore properties of figures which overlap and identify conditions of congruency with corresponding points and sides

ii. Draw congruent figures using minimum conditions and confirm by measuring angles and sides

iii. Appreciate the power of congruent figures by tessellation

Exploring the properties of symmetry

i. Explore the properties of figures which reflect and identify conditions of symmetry with line and its correspondence

ii. Draw symmetrical figures using conditions in appropriate location

iii. Appreciate the power of symmetry in designs

Exploring the properties of enlargement[74]

i. Explore properties of figures in finding the center of enlargement in simple case such as rectangle

ii. Draw enlargement of rectangle using ratio (multiplication of the value of ratio[75])

iii. Appreciate the power of enlargement in interpretation of map

74 General case for enlargement will be discussed in Key Stage 3, Space and Geometry.

75 Ratio and rate are discussed in Key Stage 2 under Measurement and Relations.

Strand: Data Handling and Graphs

The process of simple data handling is introduced through data representation such as using table, bar graph, line graph, bar chart and pie chart. Graphs are utilized depending on the qualitative and quantitative data used such as bar graph is for distinguishing and counting in every category. The discussion of producing the line graph includes taking data at specific intervals, suitable scale used and slope. Histogram is necessary for interpreting the data representation of social study and science, and is also used as a special type of bar graph. Average is introduced based on the idea of ratio for making the dispersion of bar chart even, and used for summarizing and comparing data on a table. *Problem-Plan–Data Analysis–Conclusion* (PPDAC) cycles are experienced through the process of data handling by using those data representation skills. Those skills are necessary for learning of sustainable development.

Topics

Arranging tables for data representations

Drawing and reading graphs for analyzing data

Using graphs in PPDAC cycle appropriately

Applying Data Handling for Sustainable Development

Arranging Tables for Data Representations

i. Explore how to collect multi category data based on a situation

ii. Explore how to arrange and read multi category data on appropriate tables

iii. Appreciate in using multi category tables in situation

Drawing and Reading Graphs for Analyzing Data

Drawing and reading line graphs for knowing the visualized pattern as basics on central tendency

i. Introduce line graphs based on appropriate situations such as rainfall, temperature and others

ii. Distinguish line graph from bar graph for observation such as increase, decrease, and no-change

iii. Introduce the graph of proportion using the idea of line graph and read the gradient by constant ratio[76]

iv. Appreciate the line graph in various situations

76 *Proportions are learnt in the Key Stage 2 under Measurement and Relations.*

Drawing and reading band graph and pie chart for representing ratio in a whole[77]

i. Explore how to scale the bar or circle for representing ratio or percent

ii. Use the band graph and pie chart for comparison of different groups

iii. Appreciate the band graph and pie chart in situation

Reading histogram[78] for analyzing frequency distribution

i. Draw a simple histogram[79] from frequency table on situations

ii. Read various histograms for analyzing data distribution

iii. Use mean[80] to compare different groups in the same situation with histograms

Using Graphs in PPDAC[81] Cycle Appropriately

Identifying appropriate graphs for data handling in PPDAC cycle

i. Critique a situation and discuss the expectation before taking data for proper clarification of the objective

ii. Plan the survey for the expectation

iii. Take the data based on the objective of the situation

iv. Use appropriate graphical representation which is most suitable for the objective

v. Appreciate the use of graphs before making the conclusion

Applying Data Handling for Sustainable Living

Applying data handling for sustainable development[82] and appreciate the power of data handling for predicting the future.

i. Read data related to sustainable development such as emergency preparedness and resiliency , food and energy security, world weather warming, inclusion and human connectivity in society, and lifelong learning in the changing society such as TVET (Technical and Vocational and Training) and adopting positive views for changing the society

77 Ratio is learnt under Key Stage 2 Measurement and Relations.

78 How to draw histogram is discussed in Key Stage 3 under Statistics and Probability. Reading histogram is necessary in Social Studies and Science.

79 Using ICT for drawing graph will be mentioned in mathematical activities.

80 Mean is introduced as average in Key Stage 2 under Measurement and Relations.

81 PPDAC itself will be described in the mathematical activities later.

82 This standard is related to SDG as inter subject content between Social Studies and Science.

ii. Understand the idea of probability as ratio and percentage in reading the data for situations related to sustainable development such as weather report and risk analysis

iii. Experience a project of reasonable size in data handling purposes for sustainable development and appreciate the power of data handling

Strand: Mathematical Processes – Humanity

As a follow up of Key Stage 1, activities are designed to enable an appreciation of knowledge and skills learned and the ways of learning such as applying knowledge of number sense to solve daily problems. Mathematical processes such as communication, reasoning are used to provide explanation for mathematical problems and modelling. The ability to connect and reason mathematical ideas would trigger an excitement among learners. Discussions of misconceptions are usually enjoyable and challenging. Mathematics learning usually begins from situations at Key Stage 1. In Key Stage 2, the development of mathematics is possible through the discussions for the extension of the forms. Appreciation of ideas and representations learned become part of the enjoyable activities. Through the consistent use of representations such as diagrams, application of learning becomes meaningful.

Standards

Enjoying problem solving through various questioning and conjecturing for extension of operations into decimals and fractions with proportionality and new quantities such as area and volume

Enjoying measuring through settings and using the area and volume in situations

Using ratio and rate in situations

Using number lines, tables, and area diagrams for representing operations and relations in situations

Establishing the idea of proportion to integrate various relations with consistency of representations

Enjoying tiling with various figures and blocks

Producing valuable explanation based on established knowledge, shareable representations and examples

Performing activities of grouping and enjoy representing with Venn diagram

Experiencing PPDAC (Problem-Plan-Data Analysis-Conclusion) cycle and modelling cycle in simple projects in life

Preparing sustainable life with number sense and mathematical representations

Utilizing ICT tools as well as notebooks and other technological tools

Promoting creative and global citizenship for sustainable development of community using mathematics

Enjoying problem solving through various questioning and conjecturing for extension of operations into decimals and fractions with proportionality and new quantities such as area and volume[83]

i. Pose questions to develop division algorithm in vertical form using multiplication and subtraction

ii. Pose questions to develop multiplication and division of decimal numbers using the idea of proportionality with tables and number lines

iii. Pose questions to develop multiplication and division of fractions using the idea of proportionality with tables, area diagrams and number lines

iv. Pose questions to extend multiplication and division algorithm in vertical form to decimal numbers and discuss about decimal points

v. Pose questions to use decimals and fractions in situations

vi. Pose questions to use area and volume in life

vii. Pose questions to use ratio and rate in life

viii. Pose conjectures based on ideas learned such as when multiplying, the answer becomes larger

Enjoying measuring through settings and using the area and volume in situations

i. Compare directly and indirectly areas and volumes

ii. Set tentative units from difference for measuring area and volume[84]

iii. Give the formula for the area and volume for counting units

iv. Use measurement for communication in daily life

Using ratio and rate in situations[85]

i. Understand division as partitive (between different quantities) and quotative (between same quantity) in situations

ii. Develop the idea of ratio and rate utilizing the idea of average and per unit with tables and number lines

iii. Communicate using the idea of population density and velocity in life

83 This is connected to the three strands, Extension of Numbers and Operations, Measurement and Relations, and Plane Figures and Space Solids.

84 Euclidean algorithm is a method of finding the largest common divisor of two numbers.

85 Ratio and proportion bridge multiplication and division in situation of two quantities with reference to Extension of Numbers and Operations and Measurement and Relations.

Using number lines, tables, and area diagrams for representing operations and relations in situations[86]

i. Represent proportionality on number lines with the idea of multiplication tables

ii. Use number lines, tables, and area diagrams for explaining operations and relations of proportionality in situations

Establishing the idea of proportion to integrate various relations with consistency of representations[87]

i. Use the idea of proportion as the relation of various quantities in life

ii. Identify through the idea of proportion using tables, letters, and graphs

iii. Adopt the idea of proportion to angles, arcs and area of circles

iv. Adopt the idea of proportion to area and volume

v. Adopt the idea of proportion to enlargement

vi. Use ratio for data handling such as percent and understand the difficulties to extend it to proportion

Enjoying tiling with various figures and blocks[88]

i. Appreciate to produce parallel lines with tessellation of figures

ii. Explain the properties of figures in tessellations by reflections, rotations and translations

iii. Develop nets from solids and explain the properties of solids by each of the component figures

iv. Use the idea of tiling for calculating the area and volume

Producing valuable explanations based on established knowledge, shareable representations and examples

i. Establish the habit of explanation by referring to prior learning and ask questions using terms such as why, how, what, if and if not, and reply using examples and 'for example' in discussion

ii. Assessing the appropriateness of explanations using representations such as generality, simplicity and clarity

iii. Use other's ideas to produce better understanding

iv. Use inductive reasoning for extending formulas

86 This is a bridge to the Extension of Numbers and Operations and Measurement and Relations.
87 Bridge to the three strands, Measurement and Relations, Plane Figures and Space Solids and Data Handling and Graphs.
88 Connected to the two strands, Measurement and Relations, and Plane Figures and Space Solids.

Performing activities of grouping and enjoy representing with Venn diagram

i. Use the idea of Venn diagram for social study

ii. Understand classifications based on characteristics and represent by using Venn diagrams

Experiencing PPDAC (Problem-Plan-Data Analysis-Conclusion) cycle and modelling cycle in simple projects in life

i. Understand the problem of context

ii. Plan appropriate strategies to solve the problem

iii. Gather data and analyse using appropriate methods and tools

iv. Draw conclusion with justification based on data analysis

Preparing sustainable life with number sense and mathematical representations[89]

i. Use minimum and sequential use of resources in situations

ii. Use data with number sense such as order of quantity and percentage for the discussion of matters related to sustainable development

iii. Estimate the efficient use of resources in situations

iv. Maximize the use of resources through appropriate arrangement in a space such as a room

v. Understand "equally likely" of resources in situations

Utilizing ICT tools as well as notebooks and other technological tools

i. Use internet data for the discussion of matters related to sustainable development

ii. Distinguish appropriate or inappropriate qualitative and quantitative data for using ICT

iii. Use calculators for organizing data such as average

iv. Use calculators for operations in necessary context

v. Use projectors for sharing ideas as well as board writing

vi. Enjoy using of notebooks to exchange learning experiences between each other such as in mathematics journal writing

vii. Use protractors, triangular compasses, straight edges, clinometers for drawing and measuring

89 It is related to Numbers and Operations, Pattern and Data Representations and Quantity and Measurement all under Key Stage 1.

viii. Use the idea of proportionality to use mechanism such as rotate once and move twice (wheels, gears)

ix. Use various tools for conjecturing and justifying

Promoting creative and global citizenship for sustainable development of community using mathematics

i. Utilize notebooks, journal books and appropriate ICT tools to record and find good ideas and share with others

ii. Prepare and present ideas using posters and projectors to promote good practices in the community

iii. Listen to other's ideas and ask questions for better designs

iv. Utilize information, properties, models and visible representations as the basis for reasoning

v. Utilize practical arts, home economics and outdoor studies to investigate local issues for improving welfare of life

Chapter 4

Key Stage 3

Key Stage 3 (KS3) can be learned based on the Key Stage 2. This stage learns number and algebra[90], relations and function, space and geometry and statistics and probability. Symbolic representations allow dealing abstract ideas and concepts that enhance critical thinking, creative thinking through the application of knowledge. Understanding and using of concepts and principles in this stage through participating discussions, dialogue, and arguments enable them to participate in contemporary societal, economic, technological, political, environmental and mathematical issues. This stage is the basis for the creation of better future with predictions. It bridges further mathematics learning in various job demands.

Strand: Numbers and Algebra

Numbers are extended to positive and negative numbers, and square roots. Algebraic expressions are already introduced by the mathematical sentences and symbols at KS2. At Key Stage 3, algebra is operated by expressions and equations until second degree. On the extension from numbers to symbolic algebra, various possible ways of calculations are explored until its appropriateness is established. Like and unlike terms are introduced in an algebraic sentence and in simplifying expressions. Properties of equations are introduced for finding simple equivalent and solving equations with fluency. Substitution, addition and subtraction of equations enable further operations of simultaneous equations. Expansion and factorization enable further operations of the polynomials. Finally, quadratic equations can be solved using various operations.

Topics:

Extending numbers to positive and negative numbers

Utilizing letters for algebraic expression and equations

Algebraic expressions, monomial and polynomials and simultaneous equation

Expansion and factorization of polynomial

Extending the numbers with square roots

Solving quadratic equations

90 In algebraic notation of numbers, addition and multiplication are major operations. Subtraction can be represented by addition of negative numbers and division can be represented by reciprocal or multiplicative inverse property.

Extending Numbers to Positive and Negative Numbers

Extending numbers to positive and negative numbers and integrate four operations into addition and multiplication

i. Understand the necessity and significance of extending numbers to positive and negative numbers in relation to directed numbers with quantity[91]

ii. Compare numbers which is larger or smaller on the extended number line and use absolute value for distance from zero

iii. Extend operations to positive and negative numbers and explain the reason

iv. Get efficiency on calculation in relation to algebraic sum

Utilizing Letters for Algebraic Expression and Equations

Extending the utilization of letters for general representation of situations and search the ways of simplifying of algebraic expression

i. Appreciate the utilization of letter for general representation of situations to see the expression as process and value

ii. Find the ways to simplify expressions using distribution law and figural explanations, establish the calculation with like and unlike letter

iii. Acquire fluency of simplifying expression and appreciate it for representing the pattern of situation

Thinking about set of numbers in algebraic expression with letters as variables and represent them with equality and inequality

i. Recognize numbers as positive and negative numbers, and explain integers as a part of numbers

ii. Represent a set of numbers using variables with equality and inequality

iii. Translate given sets of numbers on the number lines using interval and inequality notations

iv. Appreciate redefining of even and odd numbers using letters to represent different sets of variables

91 The study of negative numbers such as temperature is necessary in Science, Home Economics and Social Studies. For that reason, negative numbers are introduced in other subjects in Key Stage 2.

Thinking about how to solve simple linear equation

i. Review the answers of equations from the set of numbers and thinking backward

ii. Know the properties of equations which keep the set of answers of equation

iii. Appreciate the efficient use of the properties of equations to solve linear equation

iv. Use equations based on life situations to develop fluency, to solve equation, and interpret the solution

Algebraic Expressions, Monomial and Polynomials and Simultaneous Equation

Thinking about the calculations of monomial and polynomials, simple case[92]

i. Introduce term, monomial and polynomials

ii. Introduce a number raise to a power of two as square, and a number raise to a power of 3 as cube

iii. Get fluency for the calculation of polynomials such as combining like terms and the use of the four operations in simple cases

Thinking about how to solve simultaneous equation in the case of linear equations

i. Understand the meaning of solution of linear equations and simultaneous linear equation as a pair of numbers

ii. Know the substitution and elimination methods of solving simultaneous linear equations[93]

iii. Get fluency for selecting the methods from the form of the simultaneous linear equations

iv. Appreciate simultaneous linear equation on the situation

92 Simple case may vary from and depending on the countries based on the mapping of curriculum.
93 Understanding two ways of solving simultaneous equations maintains the set of answer to both equations in higher level of Mathematics.

Expansion and Factorization of Polynomial

Acquisition to see the polynomial in second degree with expansion and factorization and use it

i. Use the distributive law to explain the formulae for expansion and explain them on diagrams

ii. Get proficiency for selecting and using the appropriate formula

iii. Use the expansion formula to factorize the second degree expression and recognize both formula with inverse operation

iv. Solve simple second degree equation using the factorization and apply on life situations

Extending the Numbers with Square Roots

Extending the numbers with square roots and calculate the square roots algebraically

i. Define the square root and discuss the existing length and identify the nearest value by sandwich theorem

ii. Understand some of square roots cannot be represented by the fractions[94]

iii. Compare square root using the number line and understand that order does not change but distance

iv. Think about multiplication and addition of square root and understand the algebraic way of calculation similar to polynomial

v. Appreciate square roots in applying to situations in life[95]

Solving Quadratic Equations

Solving simple second degree equation using the factorization and apply on the situation

i. Find the answers of simple second degree quadratic equations by substitution and explore by completing the square, quadratic formula, and factorization[96]

ii. Get fluency to select the appropriate ways for solving quadratic equations

iii. Apply quadratic equations in life situations

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94 Not necessary students are to explain however without explanation we cannot introduce rational and irrational numbers.

95 Pythagorean Theorem is discussed in Space and Geometry strand.

96 The graph of quadratic equation will be treated in the Relations and Functions strand.

Strand: Relations and Functions

Relationships are represented by equations and system of equations. Functional relations are treated amongst situation, table, and equation of function are introduced based on patterns and relations with algebraic representation on Key Stage 2 and Key Stage 3. Solution of simple equation is done by equivalence deduction based on algebra learnt earlier. Two variables in simultaneous equations as simple system of equations are solved by substitution and additive-subtractive methods. Three representations, table, equation and graph, are used as methods to analyze the properties of every function. Proportion and inverse proportions are redefined with those representations mentioned. Proportional function is extended to line functions. The comparisons of inverse proportion and line functions are made clear by the property of linearity with 'constant ratio of change'. The concept of proportion is extended to function of $y = ax^2$. Ways of translations between table and equation, equation and graph, graph and table are specific skills for every function with fluency.

Topics:

Extending proportion and inverse proportion to functions with variables

Exploring linear function in relation to proportions

Exploring simple quadratic function

Generalizing functions

Extending Proportion and Inverse Proportion to Functions with Variables

Extending proportion and inverse proportion to functions with variables on positive and negative numbers

i. Extend proportions to positive and negative numbers, using tables and equations on situations

ii. Plot set of points as graph for proportions defined in ordered pairs (x, y) in the coordinate plane using appropriate scales precisely[97]

iii. Introduce inverse proportion using tables, equations and graphs

iv. Introduce function as correspondences of two variables in situations

v. Explore the property of proportional function with comparison of inverse proportional function

vi. Appreciate proportion and inverse proportion functions in life

97 Utilizing ICT is recommended in mathematical activities.

Exploring Linear Function in Relation to Proportions

Exploring linear function in relation to proportion and inverse proportions

i. Identify the linear equation on the situations with tables and compare it with proportional function

ii. Explore properties of linear function by tables, equations and graphs and comparing it with direct and indirect proportional function

iii. Acquire fluency to translate the rate of change represented in a table, coefficient in an expression and slope in graph[98]

iv. Acquire fluency to translate y values of $x = 0$ in a table, constant in an expression, and y intercept in graph

v. Apply the graph of linear function to solve simultaneous equations

vi. Apply the linear function for data representation on situations to determine best fit line

Exploring Simple Quadratic Function

Exploring quadratic function $y = ax^2$ in relation to linear function

i. Identify the quadratic function on the situations with tables and compare it with linear function

ii. Explore properties of quadratic function by tables, equations and graphs and comparing it with linear function

iii. Apply the quadratic function on situations in daily life and appreciate it

Generalizing Functions

Generalizing functions with various representations[99] on situations

i. Distinguish domain, range and intervals and is appropriately use for explaining function

ii. Use various situation for generalizing ideas of functions such as moving point A and moving point B with time

iii. Compose a graph as a function of two or more graphs with different domains in a situation

iv. Introduce situations of step-functions[100] with graph for generalization the idea of function which cannot be represented by equation

98 Family of linear functions recommends the use of ICT tool in mathematical activities.
99 Utilizing functions as model in daily life which is necessary for STEM education.
100 Intervals are taught in Key Stage 3 Numbers and Algebra.

Strand: Space and Geometry

Space and Geometry provide the ways of reasoning for exploring properties in geometry and produce the ways of argument to explain justifications of visual reasoning. The calculations of angles are not just simple calculation but also the ways of using the geometric propositions to justify answers through explaining why it is correct based on basic properties. By explaining the relationship of figures using transformation, the properties of congruency and describing similarity are identified and described. Finding the value of angles and building arguments for proving are means for developing the habit of reasoning in the properties of plane figures. The conditions of congruence and similarities, properties of circles, are also used to explain and prove appropriateness of geometric conjectures in relation to triangles, quadrilaterals, and circles. Dynamic geometric software as well as simple compass and ruler are used for conjecturing. It shows general ideas from consistency in variations. Counter example is also found as special case from variations.

Topics

Exploring angles, construction and designs in geometry

Exploring the space with its components

Exploring the ways of argument for proving and its application in geometry

Exploring Angles, Construction and Designs in Geometry

Exploring angles to explain simple properties on the plane geometry and do the simple geometrical Construction[101]

i. Explain how to determine the value of angles using the geometrical properties of parallel lines, intersecting lines , and properties of figures

ii. Use ruler and compass to construct a simple figure such as perpendicular lines and bisectors

iii. Appreciate the process of reasoning that utilizes the properties of angles and their congruency in simple geometrical constructions)

101 Simple geometric construction is discussed by the ruler and compass with reasoning. Dynamic Geometric software usually draws entire circles. For knowing invariant, dynamic geometric software is useful.

Exploring the relationship of figures using congruency and enlargement for designs

i. Explore the congruence of figures through reflection, rotation and translation and explain the congruency using line of symmetry, point of symmetry and parallel lines

ii. Explore similarity of figures with enlargement using points, ratio, and correspondences

iii. Enjoy using transformations in creating designs

Exploring the Space with its Components

Exploring space by using the properties of planes, lines and their combinations to form solids

i. Explore the properties produced by planes, lines and their combinations, such as parallel lines produced by intersection of parallel planes with another plane

ii. Produce solids by combining planes such as nets and motion such as rotation, reflection and translation

iii. Recognize the space of an object based on its properties and projection in life

Exploring the Ways of Argument for Proving and Its Application in Geometry[102]

Exploring properties of congruency and similarity on plane geometry

i. Explore ways of arguments using the congruence of two triangles and appreciate the logic of argument in simple proving

ii. Explore ways of arguments using the similarity of two triangles based on ratio and angles and appreciate the logic of arguments in simple proving

iii. Explore the proof of the properties of circles such as inscribed angles, intercepted arcs

iv. Appreciate the order of proving properties

102 Dynamic Geometric software is useful to find the invariant properties which is discussed in Mathematical Process and Humanity strand in Key Stage 3.

Exploring Pythagoras' theorem in solving problems in plane geometry and spaces

i. Explore the proving of Pythagoras' theorem using diagram and use it in solving problems involving plane figures

ii. Apply Pythagoras' theorem on the prism by viewing the figures through faces

iii. Explore the situations for simple trigonometry using special angles in relation to the Pythagorean theorem

iv. Appreciate the use Pythagoras' theorem in life[103]

Strand: Statistics and Probability

Data handling are extended to explore the dispersion of histogram with mean, median, mode and range. Exploratory Data Analysis (EDA) attempting to represent and visualize the structure from the given data using Information and Communications Technology (ICT) is enhanced. Histogram shows different dispersion if we change the class. Probability is introduced as ratio with the law of large numbers. Sample space with assumption of equal probability becomes the point of discussion. Logical analysis to understand whole possible cases such as a tree diagram is introduced for knowing the ways to represent logical reasoning. Histogram can be seen relatively and produce frequency distribution polygon. Difference between sample and population is discussed. Boxplots with quartile is an extension of median and range is used for comparisons of distributions. Using skills of statistics and probability make problem solving in situations possible. Analyzing and identifying the trends in situations for making decisions are necessary such as issues for sustainable living.

Topics:

Exploring distribution with the understanding of variability

Exploring probability with law of large numbers and sample space

Exploring statistics with sampling

Exploring Distribution with the Understanding of Variability

Exploring distribution with histograms, central tendency to represent variability

i. Investigate histogram to show distribution appropriately using class and range

103 Pythagoras' theorem is used for re-understanding the topic on square root under Key Stage 3 Numbers and Algebra.

ii. Identify alternative ways to show distribution such as dot plots, box-plot and frequency distribution polygon

iii. Investigate central tendencies such as mean, median, mode[104], quartile and their relationship on the distribution

iv. Investigate dispersion such as class, interval, range and bimodal

v. Appreciate the analysis of variability through the finding of the hidden structure of distribution on situation using the measure of central tendency and dispersion

Exploring Probability with Law of Large Numbers and Sample Space

Exploring probability with descriptive statistics, law of large numbers and sample space

i. Experiment with the help of coins and dice to explore the distribution of ratio and understand the law of large numbers

ii. Use the idea of equally likely for inference to get the value of probability[105]

iii. Analyze the situation with tables to represent the sample space and using it for predicting with probability

iv. Use various representations such as table, tree diagram , polygon diagram and frequency distribution polygon for finding probability

v. Analyze the discussion of matters related to sustainable development with probability and inference from the data to forecast the future

Exploring Statistics with Sampling

Exploring sampling with the understanding of randomness

i. Discuss the hidden hypothesis behind sample and population ratio

ii. Use randomness to explain sampling

iii. Analyze the data exploratory such as dividing the original into two for knowing better data representations and discuss appropriateness such as regrouping

iv. Appreciate data sampling in a situation with sustainable development

104 Mean, median and quartile are fixed depending on the data. However, mode changes depending on the class.
105 The probability here is called equiprobability when all possible cases are "equally likely". On the upper grade level, probability will be redefined based on distributions.

Strand: Mathematical Processes – Humanity

Enhance the critical argument in mathematics on communication with others beyond Key Stage 2. Propose challenging activities to promote metacognitive thinking at different level of arguments to make sense of mathematics. Translating real life activities into mathematical models and solving problems using appropriate strategies are emphasized in functional situations. The process of doing mathematical activities involves patience that develops perseverance in learners and takes responsibility of one's own learning. At this stage, the habitual practice of self-learning will eventually develop confidence, thus, opportunity for challenges to extend mathematics and the ability to plan sequence of future learning are also enhanced.

Standards

Enjoying problem solving through various questioning for extension of operations into algebra, space and geometry, relationship and functions, and statistics and probability

Enjoying measuring space using calculations with various formulas

Producing proof in geometry and algebra

Utilizing tables, graphs and expressions in situations

Using diagrams for exploring possible and various cases logically

Exploring the graph of functions by rotation, by symmetry and by translation of proportional function

Understanding the ways for extension of numbers

Designing models for sustainability using mathematics

Utilizing ICT tools as well as other technological tools

Promoting creative and global citizenship for sustainable development of society using mathematics

Enjoying problem solving through various questioning and conjecturing for extension of operations into algebra, space and geometry, relationship and functions, and statistics and probability[106]

i. Pose questions to extend numbers and operations into positive and negative numbers, algebraic operations, and further extension into polynomial operations, and numbers with square roots

ii. Pose questions to solve linear equations, simultaneous equations and simple quadratic equations

106 Connected to the three strands, namely Numbers and Algebra, Relations and Functions, and Space and Geometry.

iii. Pose assumptions in geometry as objects of argument and proof

iv. Pose questions to transform three dimensional objects into two dimensional shapes and vice versa

v. Pose questions in relations and functions for knowing properties of different types of function

vi. Pose questions to exploratory data handling for knowing structure of distribution

vii. Pose questions that apply PPDAC in relation to statistical problem solving

viii. Pose questions in relation to "equally likely" events

ix. Pose assumptions to discuss hypothesis based on sample and population

x. Pose conjecturing such as if x increases and y decreases then it is inverse proportion

Enjoying measuring space using calculations with various formulas[107]

i. Extend the number line to positive and negative numbers and compare the size of numbers with the idea of absolute value

ii. Derive the square root using unit squared paper through the idea of area

iii. Explain the expansion of polynomials using area diagrams

iv. Use the projection of space figures to plane figures using the Pythagorean theorem

v. Apply similarity and simple trigonometry for measurement

vi. Use the common factors to explain factorization of area of rectangle based on area of square

Producing proof in geometry and algebra

i. Have an assumption through exploration and produce propositions

ii. Justify the proposition using examples and counter examples for understanding

iii. Rewrite propositions from sentence to mathematical expressions by using letters and diagrams

iv. Search the ways of proving by thinking backward from the conclusion and thinking forward from the given

107 Connected to the three strands, namely Numbers and Algebra, Relations and Functions, and Space and Geometry.

v. Show the proof and critique for shareable and reasonableness

vi. Deduce another propositions in the process of proving and after proving using what if and what if not

vii. Adapt ways of proving to other similar propositions of proof

viii. Explain the written proof in geometry and algebra by the known

ix. Revise others' explanation meaningfully

Utilizing tables, graphs and expressions in situations[108]

i. Explore the properties of functions by using tables, graphs and expressions and establish fluency of connections among them for interpreting functions in context

ii. Analyze distribution of raw data by using tables, graphs and expressions in daily life

Using diagrams for exploring possible and various cases logically[109]

i. Use number line with inequality to identify range and set

ii. Use circle to identify relationship between circumference and central angle (acute, obtuse and right)

iii. Use rectangle and rotating a point on the side rectangle to draw the graph of the area

iv. Use tree diagram for thinking about all possible cases sequentially

Exploring the graph of functions by rotation, by symmetry and by translation of proportional function[110]

i. Use the slope of graph for the proportional function to rotate the graph or to determine the point of intersection

ii. Explore to know the nature of two simultaneous equations by using translation

iii. Use the y-axis, x-axis and y=x as the line of symmetry to explore proportional function

iv. Explain the graph of linear function by translation of proportional function

108 Connected to the strand on Relations and Functions.
109 Connected to the two strands on Relations and Functions, and Space and Geometry.
110 Connected to the two strands on Numbers and Algebra, and Relations and Functions.

Understanding ways for extension of numbers[111]

i. Extend the numbers based on the necessity of solving equations such as $x + 5 = 3$ and $x^2 = 2$, and show examples for demonstrating the existence such as on the number lines, and understand it as set

ii. Compare the size of number and identify how to explain the order of numbers and its equivalence

iii. Extend the operations for keeping the form[112] beyond the limitations of meaning[113]

Designing models for sustainability using mathematics[114]

i. Discuss and utilize probabilities in life such as weather forecasting for planning

ii. Design cost saving lifestyle models through comparison of data such as cost of electricity, water consumption, and survey

iii. Plan emergency evacuation such as heavy raining and landslide where the calculations on the amount of water in barrel per minute exceeds the maximum standards

iv. Forecast the future with mathematics

Utilizing ICT tools as well as other technological tools

i. Use dynamic geometry software for assumption, specialization and generalization

ii. Use graphing tool for comparison of the graph and knowing properties of function

iii. Use data to analyze statistics with software

iv. Use internet data for the discussion of sustainable development

v. Use calculators for operations at necessary context

vi. Use projector for sharing ideas such as project survey, reporting and presentation

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111 Connected to the strand on Numbers and Algebra.

112 There are three meanings of form: (1) Permanence of form means "keep the pattern of operation" such as (-3)x(+2)=-6, (-3)x(+1)=-3, (-3)x0=0, and (-3)x(-1)=+3, and (-3)x(-2)=+6. Here, the product of the pattern increases by 3; (2) The form means "Principle of the permanence of equivalence of form" which means to keep the law of commutativity, associativity and distributivity; and (3) The form means the axiom of field in Algebra. Normally, in education, we only treat (1) and(2).

113 For the extension of the number to positive and negative numbers, beyond the limitations of meaning such as subtract smaller number from larger number. For the extension of numbers to irrational number, beyond the limitation of meaning such as rational number is quotient (value of division).

114 Connected to the three strands, Numbers and Algebra, Relations and Functions, and Space and Geometry.

vii. Use the idea of function to control mechanism

viii. Use ICT tools for conjecturing and justifying to produce the object of proving

Promoting creative and global citizenship for sustainable development of society using mathematics

i. Utilize notebooks, journal books and appropriate ICT tools to wisely record and produce good ideas for share with others

ii. Prepare and present ideas using posters, projectors, pamphlets and social media to promote good practices in society

iii. Promote the beautifulness, reasonableness and simplicity of mathematics through contextual situations in the society

iv. Listen to other's ideas and ask questions for better designs, craftsmanship and innovations

v. Utilize information, properties, models and visible representations as basis for making intelligent decisions

vi. Utilize practical arts, home economics, financial mathematics and outdoor studies to investigate local issues for improving welfare of life

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COMMON CORE REGIONAL LEARNING STANDARDS IN SCIENCE

Chapter 5

Framework for CCRLS in Science

Nature of Science

There is no consensus and disagreement exists among philosophers of science, historians of science, scientists, and science educators on the specific definition for nature of science. Somehow this can be attributed to the multifaceted nature of science and complexity of scientific endeavour. However, briefly, nature of science refers to the epistemology of science, science as a way of knowing, or the values and beliefs inherent to the development of scientific knowledge. Review of literature presents characteristics of scientific knowledge, namely; scientific knowledge is tentative and subject to change; scientific knowledge is empirically based and in part derived from observations of the natural world; scientific knowledge is subjective (theory-laden); scientific knowledge necessarily involves human interference, imagination and creativity (involves the invention of explanations; and scientific knowledge is socially and culturally embedded (Lederman, 2013).

According to some authors the most salient feature of scientific knowledge is its systematicity. The systematic character of scientific knowledge can be examined with respect to five features of science, namely; how science describes, how science explains, how science establishes knowledge claims, how science expands knowledge and how science represents knowledge. These features of scientific knowledge are systematic. Scientific descriptions represent the first aspect of the systematicity of scientific knowledge. In the laboratory sciences, scientists aim for general descriptions that is, descriptions that provide generalizations about a certain domain of phenomena or the regularities holding in this domain. Science classifies phenomena in a systematic fashion. Generalized descriptions can be used to predict, control, or explain phenomena of the same kind. Scientists want to dig deeper than a mere knowledge of these regularities that can be observed and described. Scientists want to understand the regularities of the world.

Science typically creates theories. The systematic aspect of theories is very important, specifically their power to provide causal explanations which unify entire domains of phenomena. With the use of theories, the predictive power of science increases tremendously. Science purports to provide a form of knowledge that is particularly reliable and trustworthy. However, scientific knowledge is tentative and opens to different viewpoints, perspectives and interpretations. Error may arise as a result of mistakes, false assumptions,

entrenched traditions, belief in authorities, superstition, wishful thinking, prejudice, bias and even fraud. But science is extremely careful and successful in detecting and eliminating all sorts of error. Experiments allow scientists to test claims about the existence and properties of postulated theoretical entities much more rigorously compared with observations alone. Scientific knowledge is produced when community of scientists agree on empirical evidences. Knowledge that has been experimentally tested can immediately be used practically. This is because applying knowledge technologically is basically the same series of physical actions as experimenting, but with different intentions.

Systematically discovering the strengths and weaknesses of particular knowledge claims is one of the hallmarks of science. Some researchers rather emphasized the effects of human elements, such as creativity or subjectivity. Science has managed to improve and expand its knowledge to unprecedented degree through the availability of appropriate material resources. The essence of the astonishing ability of science to expand our knowledge is the fact that the stock of already existing knowledge is systematically used in order to create new knowledge. During the last few decades, close scrutiny of science has led to a move away from the idea of the scientific method. The procedures of science appear much more individually cased-based. Productive scientific work is largely fuelled by existing scientific results which it takes as models then extends. Science is much more artful and playful than a strictly rule-governed procedure. Science exploits technology. Technology is largely science based in the sense that many scientific results enter technological innovations. Science is used to create new technologies and new technologies are used to improve and extend scientific knowledge. Knowledge generation may also contain an element of chance. Science is even systematic in exploiting chance for generating new insights. The results of science can and must be presented in an orderly, systematic fashion. In the empirical sciences, important distinctions have to be made with respect to the representations of knowledge: the general has to be distinguished from the particular, the well-established from the merely hypothetical, the descriptive from the theoretical, the logically dependent from the logically independent, etc.

On the other hand there are drawbacks to the systematicity of science. The two issues stemming from the systematicity of science are specialization and fragmentation, and over-extension of science. Specialization is an effect of systematically pursuing questions that present themselves in the course of research. Specialization is the price one has to pay for systematic, in-depth knowledge. There are also counter-tendencies in science that tend to overcome specialization. These tendencies are due to systematic attempts to unify science

with the use of overarching theories, and by internally driven interdisciplinary research. But the fact remains that scientific knowledge is quite fragmented due to specialization, at least in practice. There are various negative consequences of this kind of specialization and fragmentation. There is a communication problem between science and the public, between science and science policy, and within science between different disciplines, even between sub-disciplines in the same field. This resulted to difficulty for the public to understand what is going on in science; policy-makers have difficulties setting priorities; interdisciplinary research poses special challenges; and so on. The second issue surrounding the systematic and comprehensive character of science is the over-extension of science- the belief that science really addresses everything. But science has limitations. There are essential problems which do not call for scientific solutions. It would be unrealistic to expect that the solutions to all our problems will be provided by science by itself. Instead, human beings will have to make decisions concerning priorities, concerning values, concerning conflicting priorities and values- and this both at local and global levels. In brief, these decisions are essentially political, not scientific. Science, including social sciences can only help especially in predicting the probable consequences of decisions and actions.

Aims of Science in CCRLS

Scientific and technological literacy plays a very vital role in ensuring an economically and environmentally sound development of countries. Thus the need to promote a world community of scientifically and technologically literate citizens through science education is imperative. Scientific and technological literacy for all is operationalised based on four educational pillars, namely; (1) personal development through acquisition of scientific knowledge, (2) personal mental development through use of scientific skills/processes; (3) development of individual attributes, attitudes and perceptions and (4) development of values and skills as a responsible member of society.

Science education for SEA-BES CCRLS aims to:

- develop scientific literacy whereby scientific knowledge acquired through the processes of science with technology as an enabler is applied in daily lives and used to acquire new knowledge;
- instill the ability to carry out scientific inquiry to understand the world around us;
- demonstrate the understanding of the nature of science in the process of carrying out scientific investigation;
- develop scientific skills through hands-on and minds-on experiences;

- develop understanding of the interrelationship of science with society, environment, technology, engineering and mathematics;
- demonstrate ethical behaviour, scientific attitudes and values when undertaking scientific thinking and processes; and
- demonstrate the ability to use the acquired scientific thinking and processes in making informed decision, and debating scientific and social-cultural issues.

Components of the Framework

The development of an understanding of science is important for students in today's world if they are to become citizens who can make informed decisions about themselves and the world in which they live. Students are faced with a myriad of information, and sifting fact from fiction and understanding the scientific basis of important social, economic, and environmental issues is possible only if they have the tools to accomplish this. Students' understanding of science should build throughout their schooling so that when they become adults they are able to act from a sound basis decisions when faced with diverse issues such as treatment of diseases, climate change, and the applications of technology. Across the world, there is an increased demand for those qualified to pursue the careers in science, technology, and engineering that drive the innovation and invention necessary for economic growth and improving the quality of life. To meet this demand, the SEA-BES Common Core Regional Learning Standards in Science Framework is developed under the analysis of national curriculum in SEAMEO Member Countries.

The framework for CCRLS in Science as shown in Figure 3 is developed under the three components and the discussion of humanistic and philosophical nature of science. The framework also provides the concrete ideas of science learning on the above aims.

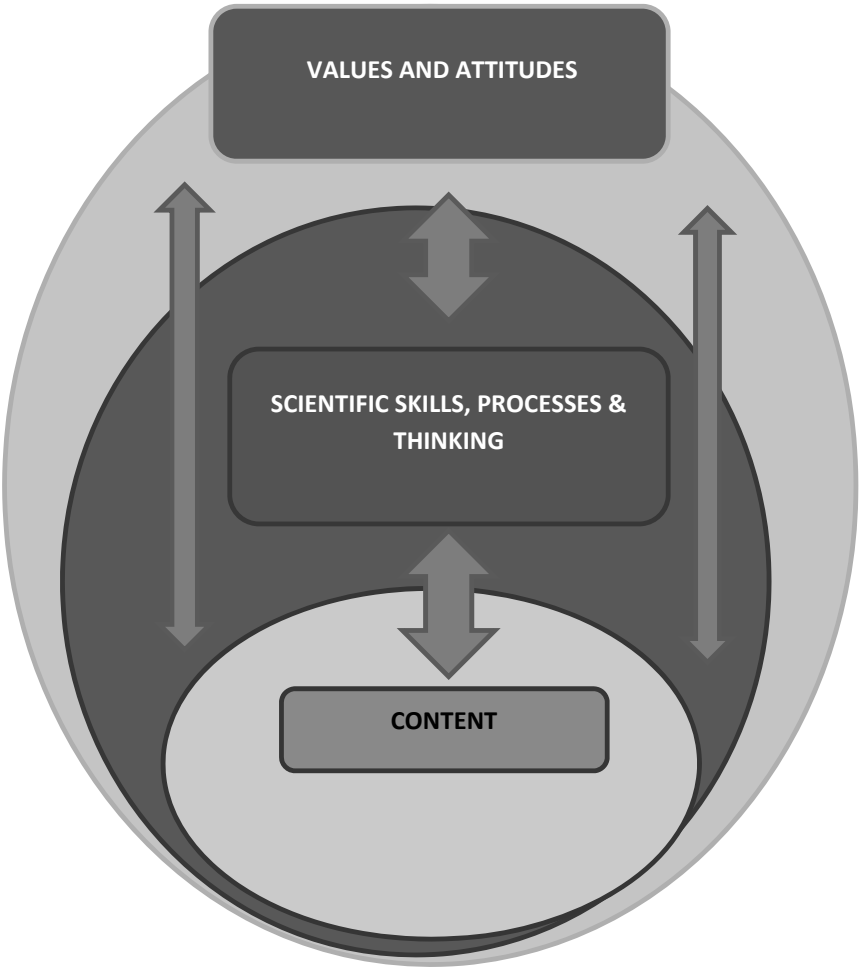

Figure 3. Components of the CCRLS Science framework.

The CCRLS framework for Science consists of three interwoven components of content, scientific skills, processes and thinking and values and attitudes. The framework is the overall structure for organizing learning and teaching for the science subjects. Table 1 shows the specific elements covered in each component of the framework.

Table 1
Components of CCRLS Science Framework

Content	Scientific Skills, Processes and Thinking	Values and Attitudes
• Scientific Inquiry • Life and the Living World • Material World • Energy and Change • Earth and Space • Science, Engineering, and Technology for Sustainable Society	**Science Skills and Process** • Questioning • Observing • Classifying • Measuring • Hypothesizing • Predicting • Inferring • Explaining • Communicating • Evaluating • Identifying and controlling variables • Formulating and testing hypothesis • Defining operationally • Interpreting data • Planning and carrying investigations **Thinking** • critical and creative thinking • reasoning • problem solving • decision making • applying and creating • generating solutions • safe use of equipment • ICT skills • Collaboration skills	• Caring for the living and non-living environment • Social awareness • Sustainability • Responsibility • Truth • Interdependence • Integrity • Perseverance • Self-discipline • Self-esteem • Empathy • Appreciation • Trust • Critical reflection • Inventiveness • Tolerance • Uncertainty • Belief and interest • Curiosity • Honesty • Objectivity • Open-mindedness • Respect for evidence

The Content Strands

The major learning contents in science are arranged into six strands yet the strands should not be viewed as compartmentalized blocks of knowledge. In order that students can have a coherent understanding of the world around them, the diversity and multiplicity of scientific facts and concepts should be learned as interrelated "bigger ideas" in a conceptual scheme. The six content strands are as follows:

- Science Inquiry
- Life and the Living World
- Material World
- Energy and Change
- Earth and Space
- Science, Engineering and Technology for Sustainable Society

Science Inquiry, and Science, Engineering and Technology for Sustainable Society may be integrated to the four content strands. The four content strands serve as the context from which science content knowledge, and scientific skills, processes and thinking as well as values and attitudes are developed in the learners across the three Key Stages.

Scientific Skills, Processes and Thinking

Scientific inquiry involves science process and thinking skills as well as general inquiry processes such as problem-solving, logical reasoning, decision-making and reflection. Science process skills are those employed by scientists to make sense of the natural world. Science process skills include questioning, hypothesizing, defining problems, generating solutions, predicting, observing, safe use of equipment, comparing, classifying, measuring, recording, inferring, analyzing, verifying, explaining, reasoning, communicating, applying and creating, evaluating and integrated science process skills of planning and carrying-out investigations.

Other generic skills which are fundamental in helping students to learn to acquire knowledge, to construct knowledge and to apply knowledge to solve new problems include decision-making skills, collaboration skills, communication skills, creative thinking skills, critical thinking skills, Information and Communications Technology, leadership skills and connectivity.

Teachers are encouraged to provide opportunities for students to use concepts and integrate skills and processes to inquire things and phenomena around them.

Skills

a) Engaging with an event, phenomena or problem through:

Formulating hypothesis: This is the skill of general explanation for a related set of observations or events. It is an extension of inferring.

Generating possibilities: This is the skill of exploring all the alternatives, possibilities and choices beyond the obvious or preferred one.

Predicting: This is the skill of assessing the likelihood of an outcome based on prior knowledge of how things usually turn out.

b) Collecting and presenting evidence through:

Observing: This is the skill of using our senses to gather information about objects or events. This also includes the use of instruments to extend the range of our senses.

Using apparatus and equipment: This is the skill of knowing the functions and limitations of various apparatus, and developing the ability to select and handle them appropriately for various tasks.

c) Reasoning, making meaning of information and evidence through:

Comparing: This is the skill of identifying the similarities and differences between two or more objects, concepts or processes.

Classifying: This is the skill of grouping objects or events based on common characteristics.

Inferring: This is the skill of interpreting or explaining observations or pieces of data or information.

Analysing: This is the skill of identifying the parts of objects, information or processes, and the patterns and relationships between these parts.

Evaluating: This is the skill of assessing the reasonableness, accuracy and quality of information, processes or ideas. This is also the skill of assessing the quality and feasibility of objects.

Communicating: This is the skill of transmitting and receiving information presented in various forms – written, verbal, pictorial, tabular or graphical.

Processes

Processes are complex operations which call upon the use of several skills. At the primary level, the processes expected of students are:

Creative problem solving: This is a process of analysing a problem and choosing an innovative and relevant solution in order to remedy or alter a problem situation.

Decision - making: This is a process of establishing and applying criteria to select from among seemingly equal alternatives. The process of establishing criteria involves consideration of the consequences and values.

Investigation: This involves formulating questions or hypotheses, devising fair methods and carrying out those methods to find out answers to the questions or to verify the hypotheses.

It must be pointed out that there is also no one definite sequence of priority among the skills and processes listed above. For example, observation may lead to hypothesising but at other times a hypothesis can lead to observation. In science teaching and learning, effort should initially be directed at teaching explicitly each of the skills through the use of appropriate activities. Later, effort should be directed to helping students integrate some or all of the skills in scientific inquiry. The skills and processes can be introduced from primary level in an age-appropriate manner. Once introduced, these skills and processes should continue to be developed at the higher levels. The skills set identified and the essential features of inquiry are shown in the table below.

<table>
<tr><td>Skills and Processes</td><td>Engaging with an event, phenomenon or problem through:</td><td>Collecting and presenting evidence through:</td><td>Reasoning; making meaning of information and evidence through:</td></tr>
<tr><td rowspan="2">Skills</td><td>• Formulating hypothesis
• Generating possibilities
• Predicting</td><td>• Observing
• Using apparatus and equipment</td><td>• Comparing
• Classifying
• Inferring
• Analysing
• Evaluating</td></tr>
<tr><td colspan="3">Communicating</td></tr>
<tr><td>Processes</td><td colspan="3">Creative problem-solving, investigation and decision-making</td></tr>
<tr><td rowspan="2">Essential features of inquiry</td><td>Question</td><td>Evidence</td><td>Explain
Connect</td></tr>
<tr><td colspan="3">Communication</td></tr>
</table>

Thinking

Thinking is a mental process that requires an individual to integrate knowledge, skills and attitude in an effort to understand the environment. Thinking skills can be categorized into critical thinking skills and creative thinking skills. A person who thinks critically always evaluates an idea in a systematic manner before accepting it. A person who thinks creatively has a high level of imagination, able to generate original and innovative ideas, and able to modify ideas and products. Critical thinking skills include attributing, comparing and contrasting, grouping and classifying, sequencing, prioritising, analyzing, detecting bias, evaluating and making conclusions. Creative thinking skills include generating ideas, relating, making inferences, predicting, making generalisations, visualizing, synthesizing, making hypothesis, making analogies and inventing. Reasoning is a skill used in making logical, just and rational judgements. Decision making involves selection of the best solution from various alternatives based on specific criteria to achieve a specific aim. Problem solving involves finding solutions to challenging or unfamiliar situations or unanticipated difficulties in a systematic manner.

Values and Attitudes

Values and attitudes should be permeated in the learning and teaching of science to foster the scientific ways of thinking and working.

The following is an outline of the values and attitudes advocated in the school curriculum.

Personal Values		Social	
Core values	Sustaining values	Core values	Sustaining values
• sanctity of life	• Self-esteem	• Equality	• Plurality
• truth	• Self-reflection	• Kindness	• Due process of law
• aesthetics	• Self-discipline	• Benevolence	• Democracy
• honesty	• Self-cultivation	• Love	• Freedom and liberty
• human dignity	• Principled morality	• Freedom	• Common will
	• self-determination	• Common good	• Patriotism
• rationality	• openness	• Mutuality	• Tolerance
• creativity	• independence	• Justice	• Equal opportunities
• courage	• enterprise	• Trust	• Culture and civilization
• liberty	• integrity	• Interdependence	
• affectivity	• simplicity	• Sustainability	• Heritage
• individuality	• sensitivity	• Betterment of human kind	• Human rights and responsibilities
	• modesty		• Rationality
	• perseverance		• Sense of belonging
			• Solidarity

Attitudes

- Optimistic
- Participatory
- Critical
- Creative
- Appreciative
- Empathetic
- Caring and concern
- Positive
- Confident
- Cooperative
- Responsible
- Adaptable to changes
- Open-minded
- Diligent
- With a desire to learn
- With respect for self, life, quality and excellence, evidence, fair play, rule of law, different ways of life, beliefs and opinions, the environment

Development of values and attitudes in science education are illustrated in the following:

- Learners maintain curiosity and continued interest in science.
- Learners are aware of the importance of the safety of oneself and others in the laboratory and be committed to safe practices in daily life.
- Learners develop personal integrity through observation and honest recording of experimental data and analysing experimental evidence.
- Learners show an awareness that the body of scientific knowledge is not static; and that experimental and investigatory work are important for its advancement.
- Learners develop an awareness of scientific advancement and its social, economic, environmental and technological implications.
- Learners are willing to communicate and comment on issues related to science, value the suggestions and respect the decisions of others.

- Learners develop a positive attitude in enhancing personal and community health.
- Learners appreciate the wonders of Nature and show respect and care for all forms of life.
- Learners appreciate the imminent need for conservation and act responsibly in conserving the environment.
- Learners demonstrate a continued interest and enjoyment in the pursuit of scientific knowledge.
- Learners are critical towards evidence, hypotheses and experiments.
- Learners show an awareness of the evolutionary nature of scientific knowledge, and that experimental and investigative works are important for its advancement.
- Learners develop open-mindedness, be able to show tolerance and respect towards different opinions, viewpoints, and people with different beliefs and value systems.
- Learners reflect on ways that scientific and technological developments influence the society.
- Learners are committed and show continued effort to support activities contributing to the personal and community health, protection of the environment, conservation of natural heritage, both locally and globally.
- Learners develop positive attitudes and values towards sex on matters related to the role of sexuality, parenthood, marriage, etc.
- Learners show concern for the local, national and global scientific issues and ethics arising from the conflicting use of places, environment, animal testing, use of materials and related consequences and others.
- Learners make informed and responsible decisions on matters related to their health based on scientific knowledge, evidence and objectivity.
- Learners are able to tolerate ambiguity, different opinions and people with different value systems.
- Learners are willing to contribute to the betterment of mankind in local, national and global perspectives based on the acquired scientific knowledge.

Context to Link the Three Components

The three components shown in Figure 3 previously should be embedded in every key stage as standards for the content of teaching. "Values, and attitudes", component and "Scientific skills, processes and thinking" component cannot exist without "Content" component. The first two components can be taught through teaching with the content. For teaching those three components at the same time, context is introduced as shown in Figure 4.

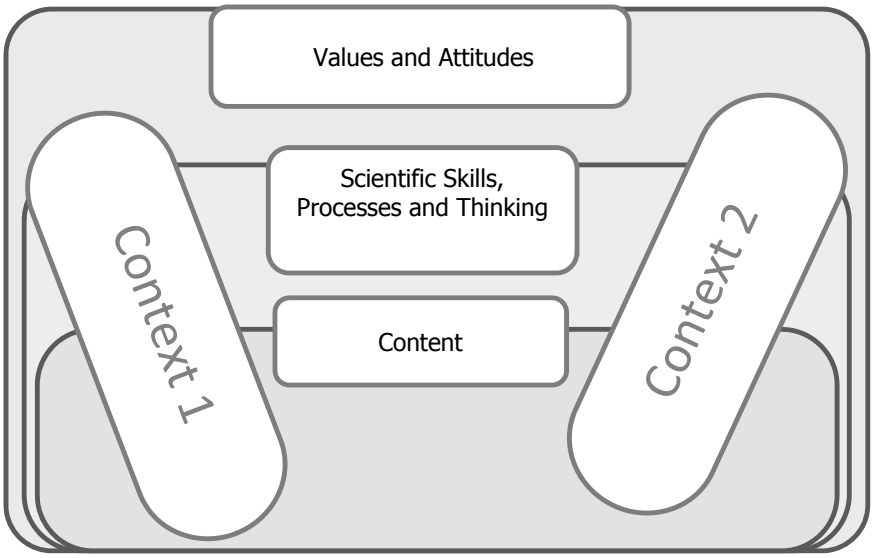

Figure 4: Interlinking of the three components with the context.

In the given context, three components are well connected. On this reason, classroom activities for developing competencies should be designed to link them. The following contexts are samples:

- Explore a problem with curiosity in a situation and attempting to formulate scientific ideas, theories and principles
- Apply the science learned, listen to other's ideas and appreciate the usefulness, power and beauty of science
- Enjoy classroom communications on science big ideas in solving problems with patience and develop persistence
- Feel the excitement of "Eureka" with enthusiasm for the solutions and explanation of unknown problems

- Think about ways of explanation using understandable representations such as language, symbols, diagrams, charts, graphs and notation of science
- Discuss the differences in seeing situations before and after learning science
- Explain, understand others and conclude scientific ideas
- Explore ideas through inductive and deductive reasoning when solving problems to foster scientific inquiry
- Feel confident in using science to analyse and solve contextual problems both in school and in real-life situations
- Promote knowledge, skills and attitudes necessary to pursue further learning in science
- Enhance communication skills with the language of science
- Promote abstract, logical, critical and metacognitive thinking to assess their own and other's work
- Foster critical reasoning for appreciating other's perspectives
- Promote critical appreciation on the use of information and communication technology in science
- Appreciate the universality of science and its multicultural and historical perspectives

Chapter 6

Science Inquiry

Strand Description

This strand aims ultimately for students to plan, carry out and evaluate own scientific investigation. This will be achieved through the development of students' process skills and the application of knowledge and understanding in structured, guided and open-ended inquiries. Habits of mind are embraced to development and application of scientific process skills, scientific ethics, attitudes and noble values in carrying out scientific investigations.

This strand involves the development of science process skills, manipulative skills, attitudes and values. It also involves the development of understanding of the importance of scientific inquiry as central to nature of science. It involves science inquiry, science process and thinking skills as well as general inquiry process such as creative thinking, problem solving, logical reasoning, decision-making and reflection. It also includes managing laboratory apparatus and specimens; safety in the laboratory; scientific ethics, attitudes and noble values; scientific investigations and the world of STEM.

In carrying out scientific investigations, students are expected to engage collaboratively with peers to develop interest and inculcate positive values about scientific learning. Experiments and investigations encourage development of knowledge and understanding in students at higher cognitive levels as they progress through the key stages. Students are able to solve everyday problems through the application of the knowledge and understanding they developed from their scientific investigations. From hands-on experiences students will develop explanations, ideas, scientific models and theories and present them through the use of ICT and other forms of representation. The process of doing scientific investigations will develop students into learners with perseverance who take responsibility for their own learning. The habitual practice of self-learning will develop them as confident and good decision makers.

This strand is not a stand-along component but should be integrated with other five (5) strands. It provides for the development of skills through hands-on and minds-on activities that are the heart of doing science.

Topic: Science Process Skills

Sub-topic: Observing

Key Stage 1

- Make simple observations of the things around using one or more senses
- Use simple science apparatus to support observation
- Observe to answer simple questions

Key Stage 2

- Make systematic and careful observations using science apparatus
- Use microscope as a tool to support observation of tiny specimens
- Make qualitative and quantitative observations
- Observe to answer simple and complex questions

Key Stage 3

- Use microscope as a tool to support observation of selected microorganisms and cells
- Use telescope and binoculars as tools to support observation
- Observe to answer complex and higher order thinking questions
- Make accurate and relevant qualitative and quantitative observations to identify patterns or sequence of events or phenomena

Sub-topic: Questioning

Key Stage 1

- Ask simple questions that can lead to an experiment or an investigation

Key Stage 2

- Ask specific questions that can lead to the design of an experiment, investigation, problem solving (which could lead to the development of a simple solution)

Key Stage 3

- Ask questions based on real life experiences, problems and issues that can lead to scientific investigations and problem solving (which could lead to the development of a simple solution)

Sub-topic: Classifying

Key Stage 1

- Group objects by observing their similarities and differences based on certain characteristics using one or more senses
- Give a name to a group of objects or specimens possessing similar characteristics
- Identify a characteristic as a basis to group the objects/specimens

Key Stage 2

- Classify objects using multistage classification

Key Stage 3

- Classify living things, matter and elements using multistage classification

Sub-topic: Identifying, Manipulating and Controlling Variables

Key Stage 1

- Identify the things that could be changed (variables) in an investigation
- Conduct simple fair test scientific investigation with teacher's support (A simple fair test investigation is when you change one variable (independent variable) measure the effect of that change (dependent variable) and keep all the other variables the same (constant variable)

Key Stage 2

- Understand the basic concept of a fair test
- Conduct a fair test that includes planning for repeat readings/observations

Key Stage 3

- Plan and conduct a whole/an open-ended fair test inquiry

Sub-topic: Hypothesising

Key Stage 1

- Make simple hypotheses with teacher's support

Key Stage 2

- Identify a variable that may affect the outcome of an investigation and make a hypothesis that states the effect of changing the variable or the outcome

Key Stage 3

- Establish a relationship between the independent variable and dependent variable to form a hypothesis that can be tested

Sub-topic: Measuring and Using Numbers

Key Stage 1

- Make measurements using non-standard units
- Make measurements using standard units for quantities such as length, mass or time

Key Stage 2

- Make precise and accurate measurements using standard units for quantities such as length, mass, volume, time and temperature
- Make measurements with increasing precision and accuracy and take repeat readings when appropriate
- Use the S.I. units and their corresponding symbols
- Use symbols and values of prefixes for unit of length, volume, time, temperature, mass and power: milli-, centi-, kilo-, deca-, square meter, cubic meter

Key Stage 3

- Choose the measuring tools and instruments appropriate for the specific scientific investigations to ensure precision and accuracy
- Determine the area and volume of irregularly shaped objects using the water displacement method

Sub-topic: Recording, Analysing and Interpreting Data

Key Stage 1

- Gather and record simple data from observation
- Record data from simple investigation
- Record findings using simple language
- Apply basic numeracy to calculate results
- Use drawing and labels to present results and use prepared simple tables and charts with support

Key Stage 2

- Use drawings, symbols, labeled diagrams, keys, and tables in recording data
- Process and analyse data to form simple conclusion
- Create own tables for investigations involving one independent variable
- Draw a bar chart with support
- Read values from the graph
- Make a general statement about simple patterns from the graph
- Describe the relationship identified, linking both the independent and dependent variables

Key Stage 3

- Interpret observations and data, including identifying patterns and using observations, measurement and data to draw conclusions
- Apply mathematical concepts and calculate results
- Create tables, charts and graphs appropriate for the investigation carried out
- Create appropriate tables, charts and graphs for the investigation carried out using ICT
- Identify relationships by applying mathematical calculation
- Extrapolate and interpolate data from graph

Sub-topic: Communicating

Key Stage 1

- Make simple reports from observations through oral and/or written forms)
- Make simple reports on findings through oral and written, drawings, display and other means of presentations

Key Stage 2

- Report and present observations, data and findings using appropriate methods, including use of ICT with some guidance

Key Stage 3

- Report and present observations, data and findings using appropriate methods, including use of ICT

Sub-topic: Evaluating

Key Stage 1

- Use evidence to answer questions or to support findings
- Recognise any of the difficulties encountered with support

Key Stage 2

- Suggest how the difficulties accounted might be avoided
- Suggest how the investigation might be improved and raise further questions
- Identify differences, similarities or changes related to simple scientific ideas and processes
- Recognise some of the limitations of the findings
- Identify evidence that can been used to support or refute ideas or arguments

Key Stage 3

- Evaluate the precision, accuracy and reliability of methods and suggest possible improvements
- Identify any anomalous result and explain how those have occurred
- Evaluate data, showing awareness of potential sources of random and systematic error

Sub-topic: Predicting

Key Stage 1

- Use results to make predictions for further investigations with support

Key Stage 2

- Use results to make predictions to set up further investigations

Key Stage 3

- Make predictions using scientific knowledge and understanding
- Analyse data obtained to predict the future phenomenon

Sub-topic: Explaining Results and Developing Solutions

Key Stage 1

- Develop simple ideas and explanations from the investigations carried out with support
- Develop solutions to problems based on evidence and data collected with support

Key Stage 2

- Develop ideas and explanations based on evidence and data collected from investigations
- Develop solutions to problems based on evidence collected from investigations
- Develop simple argument based on data and evidence collected
- Develop and design simple solutions to problems based on evidence and data collected from investigations

Key Stage 3

- Develop explanations based on scientific knowledge and understanding
- Develop idea, explanations, theories and models based on data and evidence collected
- Develop an argument based on data and evidence collected
- Develop and design complex solutions to problems based on evidence and data collected from investigations

Topic: Managing Laboratory Apparatus and Specimens

Sub-topic: Use and Handle Apparatus and Substances Correctly

Key Stage 1

- Handle apparatus correctly
- Handle a range of apparatus including thermometers, magnifying glass, ruler, etc. and simple substances

Key Stage 2

- Use a range of scientific apparatus/equipment with increasing accuracy and precision
- Use a range of apparatus/equipment appropriately

Key Stage 3

- Use appropriately and safely all laboratory apparatus/equipment

Sub-topic: Handle Specimens Correctly, Carefully and Safely

Key Stage 1

- Handle simple specimens correctly, carefully and safely with teacher's supervision

Key Stage 2

- Handle simple specimens correctly, carefully and safely

Key Stage 3

- Handle specimens correctly, carefully and safely

Sub-topic: Clean Apparatus Using the Correct Method

Key Stage 1

- Clean simple apparatus carefully using the correct method with teacher supervision

Key Stage 2

- Clean simple apparatus carefully using the correct method

Key Stage 3

- Clean apparatus carefully using the correct method

Sub-topic: Store Apparatus and Substances Correctly and Safely

Key Stage 1

- Store simple apparatus and substances correctly and safely with teacher's supervision

Key Stage 2

- Store simple apparatus and substances correctly and safely

Key Stage 3

- Store apparatus and substances correctly and safely

Sub-topic: Basic Microscopy

Key Stage 3

- Identify the basic parts of a microscope and state the function of each part
- Prepare fresh biological specimen for observation under the microscope using iodine or methylene blue as stains, (i.e. cheek cell or liver cell and onion cell)
- Draw diagrams of mounted slides observed under the microscope

Topic: Observing Safety in the Laboratory

Sub-topic: Laboratory Safety

Key Stage 1

- Identify potential hazards in the laboratory and suggest necessary precautions

Key Stage 2

- Identify potential hazards in the laboratory and suggest necessary precautions
- Make decisions on the right things to do in the laboratory in case of accident or emergency (e.g. fire or acid spills)

Key Stage 3

- Identify potential hazards in the laboratory and suggest necessary precautions
- Make decisions on the right things to do in the laboratory in case of accident or emergency (e.g. fire or acid spills)
- Demonstrate the use of fire extinguishers
- Carry out a risk assessment for the scientific investigation

Topic: Ethics, Scientific Attitudes and Noble Values

Sub-topic: Realising the Need to Practise Scientific Attitudes and Noble Values

Key Stage 1

- Internalise scientific attitudes and noble values practiced by scientists such as curiosity, open-mindedness, perseverance

Key Stage 2

- Internalise scientific attitudes and noble values practiced by scientists such as curiosity, open-mindedness, perseverance, creativity, objectivity, integrity and responsibility
- Practise scientific attitudes and noble values when planning and carrying out a scientific investigation

Key Stage 3

- Be aware that scientific methods develop with the development of new technologies and equipment
- Be aware that theories develop and change as earlier explanations are modified as a result of new data or further research collected from that research
- Be aware of the importance of publishing results and peer review
- Pay attention to objectivity and concern for precision, accuracy, reliability, repeatability and reproducibility
- Practise scientific attitudes and noble values when carrying out a scientific investigation

Topic: Scientific Investigations

Sub-topic: Planning and Conducting Investigations

Key Stage 1

- Plan and carry out simple investigations involving the application of fair test concept with support

Key Stage 2

- Plan and carry out investigations involving the application of fair test concept

Key Stage 3

- Plan and carry out the most appropriate types of scientific investigations to find answer to scientific question or test a prediction, including identifying independent, dependent and control variables, where appropriate
- Use appropriate techniques, apparatus and materials during fieldwork and laboratory work, paying attention to health and safety

Topic: The World of STEM

Sub-topic: How STEM Works

Key Stage 1

- List what they see around them that is related to STEM
- Explain the importance of STEM in everyday life

Key Stage 2

- Aware that men and women from different social, cultural and ethnic background work as scientists and engineers
- Name some careers in science such as science teachers, doctors, engineers, environmental scientists, biologists, etc.
- Realise the possibilities and limitations of scientific knowledge
- Aware of the applications of science in everyday life

Key Stage 3

- Identify scientists and engineers rely on human qualities such as persistence, precision, reasoning, logic, imagination and creativity
- Aware that scientists and engineers are guided by habits of mind such as intellectual honesty, tolerance of ambiguity, skepticism, and openness to new ideas
- Aware of advances in technology and engineering influence the progress of science, and science influences advances in technology
- Aware of the applications and implications of STEM in everyday life
- Aware of the nature/processes of science and engineering design process
- Aware of arguments develop from evidence and interpretation of evidence

Chapter 7

Life and the Living World

Strand Description

This strand aims to develop understanding of scientific concepts and principles related to the content of life and the living world. It revolves around five themes dealing on structure and function, diversity of living things, continuity of life, interaction of living things and the environment and applied biology. It includes topics on living things and non-living things; personal health and healthy lifestyle; human body and organ systems; animals; plants; ecosystem and the environment; biodiversity; microorganisms; cells and organisation; inheritance, chromosomes, DNA and genes, and biotechnology.

This strand covers the knowledge, skills and values about the living world, emphasizing life processes and the interaction between life and its surroundings. Humans, animals and plants are closely interrelated, so it is important to sustain a stable and dynamic interaction between them. The well-being of mankind is of utmost importance and everyone should acquire substantial knowledge and understanding about the human body and how to manage their health wisely.

In carrying out scientific activities, students are expected to engage collaboratively with other peers to develop interest and inculcate positive values about scientific learning. The use of challenging activities should encourage the development of higher order thinking and deep understanding of the science introduced. Students should be encouraged to solve real-world problems. Students should develop own ideas from hands-on experience including the use of scientific models. This can be achieved through the use of appropriate ICT and other representations. The use of scientific activities should encourage students to take responsibility for their learning and develop confidence and informed decision.

The students are expected to explore the things around them using scientific thinking and process skills. These skills will enhance the development of critical and creative thinking. This will lead to an accurate and appropriate reasoning and decision making in life. Students can apply critical reflection and inculcate sense of caring for living things and the environment by providing a platform for the students to develop open mindedness, curiosity, responsibility and social awareness with regard personal well-being, community and local environment.

Topic: Living Things and Non-Living Things

Sub-topic: Characteristics of Living Things and Non-Living Things

Key Stage 1

- Identify the examples of living and non-living things
- State the differences between living and non-living things
- Identify the basic needs of living things – air, water, food
- State life processes of living things (breathe, eat, grow, move, reproduce, and react to light, touch, and temperature)

Key Stage 2

- Understand the life processes of living things

Key Stage 3

- Apply the understanding of the life processes of living things

Topic: Personal Health and Healthy Lifestyle

Sub-topic: Hygiene and Safety at Home

Key Stage 1

- Describe how to clean the different parts of the body
- Explain why we need to keep the body clean
- State how to use the toilet correctly
- Explain the importance of using the toilet correctly
- Explain how each part of the body can be cleaned and cared for
- Be aware of responsibilities for ones' own health
- Name common accidents at home
- Identify how the risk of accidents can be reduced at home

Key Stage 2

- Name some contagious diseases in everyday life
- Explain various ways how the named diseases are spread
- Suggest ways on how to prevent the spread of contagious diseases

Key Stage 3

- Explain how contagious diseases are treated and the effects of the treatment
- Practise methods and measures in the prevention of contagious diseases

Sub-topic: Food and Its Importance

Key Stage 1

- Identify healthy and unhealthy food and give examples
- Give reasons why some foods are healthy and some are unhealthy for the body
- State why is it important to eat a variety of foods
- Demonstrate good food eating habits
- Explain how to handle, keep and eat food safely
- Explain the causes of diarrhea and ways to prevent it

Key Stage 2

- Differentiate the types/classes of food
- Explain the dietary importance of protein, carbohydrates, fats, vitamins, minerals, salts, water and fibre to the body
- Explain the importance of eating a balanced diet
- Plan or prepare a healthy dish or menu
- Plan how to manage the amount of food required to avoid food wastage

Key Stage 3

- Evaluate the calorific value of food
- Explain the factors that affect the total calories required by an individual
- Explain the effects of unbalanced diet with reference to malnutrition, obesity, diabetes, underweight and coronary related conditions
- Evaluate and practise the habits of healthy eating

Sub-topic: Drugs

Key Stage 2

- Differentiate between medicinal drugs and harmful drugs
- Explain that antibiotics should be taken as prescribed by doctors
- Explain the harmful effects of alcohol, cigarettes and illicit drugs on the mind and body
- Explain the harmful effects of passive smoking and addiction

Key Stage 3

- Explain the consequences of drug trafficking
- Present argument on the reasons why alcohol is harmful to health
- Explain how alcohol and illicit drugs can lead to addiction

Topic: Human Organ Systems

Sub-topic: Humans Have Basic Needs to Live

Key Stage 1

- State the basic needs of human beings in order to live

Sub-topic: Parts and Function of the Human Body

Key Stage 1

- Name the main external parts of the human body
- Draw and label the main external parts of the human body
- State the function of the external parts of the human body
- Describe the external human body parts through observation or use of ICT
- Appreciate the external human body parts
- Respect and accept one's and other's external physical condition

Key Stage 2

- Name and state the function of the systems of the human body
- Describe the internal human organs and their functions through observation or ICT
- Respect and accept one's and other's physical condition

Key Stage 3

- Explain that all body systems work together to enable functioning of the body as a whole

Sub-topic: Human Sense Organs

Key Stage 1

- Recognise information provided by the five sense organs
- State and label the parts of ears, eyes, tongue, nose and skin
- Give examples of how the five sense organs are used in everyday life activities

Key Stage 2

- Explain the functions of sensory organs

Key Stage 3

- Describe the structure of sensory organs in humans
- Explain the function of each part of the sensory organ
- Explain the limitation of sight and how to correct it

Sub-topic: Human Nervous System

Key Stage 2

- Describe how humans respond to stimulus, through activities
- Give reasons why humans respond to stimuli
- Make inferences on the importance of human beings responding to various stimuli

Key Stage 3

- Identify the main parts of the human nervous system
- Describe the gross function of the nervous system
- Explain how the parts of the nervous system work

Sub-topic: Human Respiratory System

Key Stage 2

- Illustrate the path of air during inhalation and exhalation
- Describe the movement of the chest cavity during inhalation and exhalation
- Explain how the human breathing system works
- Compare the differences between inhaled and exhaled air
- State that oxygen inhaled is needed to produce energy from food
- State that breathing rates depend on the types of human activities

Key Stage 3

- Identify the organs in the respiratory system of human beings
- Describe the main function of the respiratory system
- Describe the human breathing mechanism
- Explain the transport of oxygen in the human body
- Explain gaseous exchange in the human body

Sub-topic: Human Digestion System

Key Stage 1

- Identify the organs in the human digestive system

Key Stage 2

- Describe briefly the importance of food digestion
- Identify the products of human digestion
- Draw and label main parts of the digestive system
- Describe the functions of organs in the human digestive system
- Describe some diseases that affect the digestive system and ways to prevent them
- Identify the different types of teeth and their functions
- Draw and label the parts of the teeth
- Describe the role of teeth in mastication
- Practise good health habits to protect the teeth

Key Stage 3

- Explain what is meant by digestion
- Describe the digestive system in humans and explain how it works
- Identify the main parts of the digestive system and the processes that take place
- Describe the main function(s) of mouth, stomach, small intestine and large intestine
- Describe the role of digestive enzymes present in the mouth, stomach and small intestine (limit to the three classes of enzymes i.e. carbohydrase, protease and lipase)
- Investigate digestive enzymes
- Explain the process of digestion
- Explain the process of absorption of digested food
- Describe the process of defecation and the reabsorption of water
- Explain causes, treatment and effects of treatment on ailments affecting the digestive system

Sub-topic: Human Excretion System

Key Stage 2

- State the meaning of excretion
- Identify the excretory organs and the products of human excretion
- Explain the processes of excretion

Key Stage 3

- Describe the function of each part of the human excretory system
- State the waste products excreted through the excretory organs
- Explain the importance of the human excretory system
- Explain the health problems related to a diseased kidney
- Explain causes, treatment and effects of treatment on kidney disease

Sub-topic: Human Circulatory System

Key Stage 2

- Identify the main parts of the circulatory system
- State the gross function of the circulatory system
- Identify and explain the function of the main parts of the circulatory system
- Explain the role of the circulatory system

Key Stage 3

- Describe the structure and function of the circulatory system
- Identify the main parts of the heart and their functions
- Identify the components of the blood (i.e. white blood cells, red blood cells, platelets)
- Describe the functions of blood vessels (i.e. arteries, veins and capillaries)
- Describe the relationship of the heartbeat, pulse and blood pressure
- Compare coronary pulmonary circulation and systemic circulation
- Identify the four different blood groups
- Explain the importance of checking for blood compatibility to avoid agglutination of blood
- Explain how heart rate changes and is controlled
- Explain the integration of the digestive system, respiratory system and circulatory system in carrying out life processes

Sub-topic: Human Movement System

Key Stage 2

- State that movement is carried out by the bones and muscles
- Identify the main parts of the human skeletal system
- Describe the purpose of the human skeleton and muscles
- Draw and label the main parts of the human skeleton and the major muscles

Key Stage 3

- Explain breaks, strains and dislocations and suggest ways of preventing and treating them
- Construct a model and explain how the bones and muscles bend or straighten the arm

Sub-topic: Human Growth

Key Stage 1

- Keep a personal chart to show growth
- Construct simple timeline to show main events in own life

Key Stage 2

- Explain the factors essential for growth
- Explain human growth from birth to adulthood

Key Stage 3

- Interview an elderly persons about their growth and development, and the main physical changes they have experienced

Sub-topic: Human Reproduction System, Puberty, Pregnancy, Pre-Natal Care and Birth Control

Key Stage 2

- Describe the main function of the major reproductive organs in male and female
- Draw and label main parts of the reproductive organs of a male and female
- List common diseases that affect the human reproductive system

Key Stage 3

- Describe the structures and functions of the various parts of the male and female reproductive system
- Describe the physical, physiological and emotional changes that occur during puberty and early adolescence
- State what is meant by menstruation
- Describe menstrual cycle briefly (without details of hormones)
- Explain the hygiene aspects that should be taken care of during menstruation
- Explain what is meant by fertilization
- Describe briefly pregnancy and development of zygote
- Show an awareness of some forms of facilitated reproduction in humans (i.e. in-vitro fertilization, and artificial insemination)
- Describe the methods of birth control
- Differentiate temporary and permanent method of birth control
- Discuss the effects of maternal lifestyle on the fetus through the placenta
- Describe the physical and emotional development of pregnant woman
- State the purpose of pre-natal care
- Explain the process of conception and reproduction in human
- Identify and explain some common forms of contraception
- Explain how sexually transmitted diseases (STDs) are transmitted, treated and prevented

Sub-topic: Human Immune System

Key Stage 3

- Explain the role of antibodies in human immune system
- Explain the effects of HIV and effect of weakened immune system
- Explain vaccination and other ways to strengthen immunity

Sub-topic: Human Inheritance, Cell Division and Mutation

Key Stage 2

- State that children inherit their parents' characteristics
- Explain through examples physical characteristics of children that can be inherited from their parents

Key Stage 3

- State the types of cell division
- Explain the stages of mitosis and meiosis
- Explain the importance of mitosis in the growth, development and repair of somatic cells
- Explain the importance of variations in plant and animal breeding
- Relate DNA to chromosomes and genes
- Explain the principles and mechanisms of inheritance
- Explain the sex determination of offspring from gametes
- Explain the formation of twins in human beings
- State what mutation is
- Explain how mutation can occur in humans and its importance
- Describe the implications of mutation to real life cases
- Discuss variation among living things

Sub-topic: Human Coordination System

Key Stage 3

- State the systems that are involved in maintaining body coordination
- Describe the importance of body coordination in humans
- Explain how body coordination works

Sub-topic: Homeostasis in Humans and Animals

Key Stage 3

- Observe and explain behaviour of humans and animals in response to internal and external stimuli
- Investigate the effects of homeostasis

- Explain maintenance of cellular homeostasis
- Explain the importance of homeostasis in body temperature of humans and other animals

Topic: Animals

Sub-topic: Body Parts of Animals

Key Stage 1

- Identify the main parts of the body of animals
- Compare the body parts of different animals
- Generalise that some animals have the same characteristics while others have different characteristics as to body parts
- Classify similarities and differences within groups of animals as to body parts

Key Stage 2

- Explain that the characteristics of body parts of animals are used as bases in classification
- Explain that the characteristics of body parts of animals are suited to where they live

Sub-topic: Basic Needs of Animals

Key Stage 1

- State the basic needs of animals
- Describe the food sources for animals
- Identify shelter for animals

Key Stage 2

- Identify various ways animals take care of their eggs
- Identify various ways animals take care of their young
- Understand the importance of survival of animals

Sub-topic: Importance of Animals

Key Stage 1

- State the importance/benefits of animals to humans, plants and other animals
- Give examples of animals that are raised for production and for labour

Sub-topic: Growth Processes or Life Cycle of Animals

Key Stage 2

- Identify the ways animals reproduce (i.e. giving birth and laying eggs)
- Identify babies of animals that resemble their parent and those which are different
- Record changes/development in growth of animals such as butterfly or frog through observation
- List two external factors necessary for the completion of the life cycle of the named animal
- Make simple comparisons of life cycles of insects, fish, amphibians, reptiles, birds and mammals

Sub-topic: Breathing Structure of Animals

Key Stage 2

- Identify the breathing organs of animals through observation
- Understand that some animals have more than one breathing structure

Sub-topic: Animal Movements

Key Stage 1

- Describe the different kinds of animal movements
- Understand the importance of animal movements

Sub-topic: Animal Characteristics, Classification and Adaptations

Key Stage 1

- Identify the characteristics of the animals (Example: body parts, type of food eaten, skin covering, reproduction, locomotion, habitat, etc.)

Key Stage 2

- Classify animals based on certain characteristics
- Describe distinguishing characteristics of vertebrates and invertebrates

Key Stage 3

- Describe adaptations or special characteristics in animals which protects them from danger against enemies
- Describe adaptations or characteristics in animals which protects them from extreme weather conditions

Sub-topic: Animal Teeth and Feeding

Key Stage 2

- State the eating habits/behaviour of animals: herbivores, carnivores, omnivores
- Relate the structure of teeth of herbivores, carnivores, omnivores to the food taken
- Predict what will happen if the animals only consume one type of food/ one eating habit

Sub-topic: Interaction between Animals

Key Stage 2

- State the purpose of interaction between animals
- Explain with examples that animals live together or solitary by observation or through various media
- Describe the advantages and disadvantages of animals living in groups and solitary
- Explain the type of interaction between animals with examples, e.g. predator-prey relationship
- Describe competitive factors both intra-species and interspecies of animals by observation or through various media

Sub-topic: Endangered Animals and Conservation

Key Stage 2

- Identify endangered animals by giving examples
- Explain why animals become endangered in their natural habitat
- Identify how animals survive or become extinct due to changes in the environment
- Give examples of extinct animals
- Explain why certain animals are facing the threat of extinction
- Explain the impact of polluted water on animals

Key Stage 3

- Explain what conservation and preservation are
- Explain the steps taken to preserve and conserve animals
- Justify the importance of conservation and preservation of animals
- Support activities organised by various parties to preserve and conserve animals

Topic: Plants

Sub-topic: Parts of the Plants

Key Stage 1

- Identify the major parts of the plant: roots, stem/trunk, leaves and flowers
- Describe the function of the major parts of the plant
- Classify plant parts based on observed characteristics

Key Stage 2

- Describe the functions of different parts of flowering plants
- Explain that plant parts are used as bases in classification
- Explain that plants have certain characteristics to survive in different habitats
- Explore the importance of flowers in the life cycle of flowering plants, including pollination, seed formation and seed dispersal
- Investigate the ways in which water is transported within plants

Sub-topic: Basic Needs of Plants

Key Stage 1

- Identify the basic needs of plants to grow such as water, air and sunlight
- Understand the needs of plants to survive
- Care for plants by providing them with basic needs to grow healthily

Key Stage 2

- Investigate the importance of water, air and light to plants through simple research

Key Stage 3

- Investigate the requirements of plants for growth (air, light, water, nutrients from soil, and environment to grow) and how they vary from plant to plant

Sub-topic: The Process of Photosynthesis and Cellular Respiration in Plants

Key Stage 2

- Investigate the requirements for photosynthesis
- Communicate findings on the requirements for photosynthesis

Key Stage 3

- Identify the reactants and the products of photosynthesis
- Investigate the factors that are essential for plant photosynthesis, and explain that light, chlorophyll, carbon dioxide and water are essential for photosynthesis
- Explain the importance of plant photosynthesis for living things and the environment
- Describe the energy process during the reactions in photosynthesis
- Differentiate the basic features of photosynthesis and respiration
- Identify the structures and functions of mitochondria as the main organelle involved in cellular respiration

Sub-topic: Transportation in Plants

Key Stage 3

- Observe and explain the structures related to water and food transportation systems in plants, including xylem an phloem
- Explain the importance of the transport system in plants

Sub-topic: Excretion in Plants

Key Stage 3

- State the organs involved in excretion of plants
- List the waste products produced in plants and explain how they are excreted

Sub-topic: Plant Growth and Reproduction

Key Stage 1

- Record changes of growth in plants with respect to height, number of leaves or roots through investigation
- Observe and describe how seeds and bulbs grow into mature plants

Key Stage 2

- Describe the structures and functions of the parts of the flowers in flowering plants
- Explain asexual reproduction processes in plants including usage of various plant parts for propagation
- Conduct experiment to show that new plants may be grown from plant parts using techniques such as grafting, budding, marcotting, etc.

Key Stage 3

- Explain the role of insects and wind in pollination
- Describe the process of fertilization
- Investigate the formation of fruits and seeds and dispersal, including quantitative investigation of some dispersal mechanisms
- Investigate how plants protect themselves
- Investigate how pests and diseases affect common crops
- Investigate different methods of pest control

Sub-topic: Plant Characteristics, Classification and Adaptations

Key Stage 1

- Identify the different characteristics of plants

Key Stage 2

- Classify plants based on characteristics or criteria
- Describe the characteristics of flowering and non-flowering plants

Key Stage 3

- Recognize that plants have adaptations for protection and survival

Sub-topic: Plant Responses and Homeostasis

Key Stage 2

- Investigate how plants respond to water, light and touch to grow and stay healthy
- Describe the stimuli and responses in plants

Key Stage 3

- Investigate mechanisms for maintenance of water homeostasis in plants
- Explain mechanisms for maintenance of water homeostasis in plants

Sub-topic: Endangered Plants and Conservation

Key Stage 2

- Explain why plants become endangered in their natural habitat by giving examples
- Identify how plants survive or become extinct due to changes in the environment
- Give examples of extinct plants
- Explain why certain plants are facing the threat of extinction
- Describe the changes in physical factors in tropical rainforest, coral reef, and mangrove swamps that lead to plants becoming endangered

Key Stage 3

- Explain what conservation and preservation are
- Explain the steps taken to preserve and conserve plants
- Justify the importance of conservation and preservation of plants
- Support activities organised by various parties to preserve and conserve plants

Topic: Ecosystem and Environment

Sub-topic: Food Chain and Food Web

Key Stage 2

- Demonstrate understanding that plants use materials from the environment to make their own food
- Describe the meaning of a food chain
- Construct food chains in various habitats
- Understand the importance of food webs in ensuring survival of the species
- Identify the factors that could affect the food chain and therefore the survival of organisms
- Trace the energy pathway from the Sun through a food chain
- Explain the roles of various organisms (i.e. producers, consumers, predators, prey) in a food chain and food web
- Explain that interlinked food chains are called a food web
- Construct food webs in various habitats
- State that different habitats support different communities
- Explain the impact of human activities on the environment

Key Stage 3

- Differentiate between the terms organism, population and community
- Predict the impact of population change on the food web
- Analyse and explain the energy transfer relationships of living things in food chains and food webs
- Illustrate energy transfer and ecological relationships of living things in food chains and food webs
- Discuss the effects of unfavourable environmental changes and conditions on organisms

Sub-topic: Relationships in an Ecosystem

Key Stage 2

- Explore various ecosystems in the local area
- Explain relationships within the ecosystems (i.e. symbiosis, predation, mutualism, commensalism, etc.)

Sub-topic: Water Cycle, Nitrogen Cycle and Carbon Cycle

Key Stage 2

- Explain water cycle and the importance of this cycle to the ecosystem

Key Stage 3

- Explain nitrogen and carbon cycles and the importance of these two cycles to the ecosystem

Sub-topic: Factors Affecting Population Size

Key Stage 3

- Explain the factors affecting changes of population size in an ecosystem, including birth rate, death rate, migration, disease, predators, food resources and drought

Sub-topic: Evolution

Key Stage 3

- Explain evolution, theory of natural selection, and scientific evidence for natural selection

Sub-topic: Maintaining Equilibrium in the Environment

Key Stage 3

- Analyse problems concerning the environment and natural resources in the local area and propose solutions
- Explain guidelines for maintaining the equilibrium of an ecosystem

Topic: Biodiversity

Sub-topic: Classification of Plants and Animals

Key Stage 3

- Recognise that there is a variety of plants and animals which can be grouped according to their observable external characteristics
- Classify plants according to common observable characteristics namely, plants without seeds and seed plants
- Classify animals according to common observable characteristics namely, vertebrates and invertebrates
- Understand the existence of microorganisms such as fungi, bacteria and viruses which are not classified as either plants or animals

Sub-topic: Species Diversity

Key Stage 3

- Examine the diversity of species
- Explain the advantages of high and low biodiversity
- Explore and explain biodiversity in the local area that enable living things to co-exist in equilibrium
- Explain effects of biodiversity on humans, animals, plants and the environment

Sub-topic: Dichotomous Key and Hierarchical Taxonomic System of Species

Key Stage 3

- Construct a simple dichotomous key and use it to identify organisms
- Understand that species are further classified into a hierarchical taxonomic system
- Illustrate the hierarchical taxonomic system of species

Topic: Microorganisms

Sub-topic: Role of Microorganisms in Nature

Key Stage 1

- State that microorganisms exist that may cause illness in humans

Key Stage 2

- Identify the types of microorganisms by observation through various media
- Investigate life processes of microorganisms
- Generalise that microorganisms are living things and invisible to the naked eyes
- Investigate the factors that affect the growth of microorganisms through experiment
- Explain the usefulness and harmful effects of microorganisms

Key Stage 3

- Understand the existence of microorganisms such as fungi, bacteria and viruses which are not classified as either plants or animals
- Explain the benefits and harmful effects caused by various types of microorganisms

- Explain methods of preventing infection due to microorganisms
- Examine the different treatment of diseases caused by microorganisms
- Examine the effects of microorganisms in the balance of nature

Sub-topic: Infectious Diseases Caused by Microorganisms

Key Stage 2

- Understand that some microorganisms can cause infectious diseases and illnesses
- Explain how common infectious diseases are spread through different modes of transmission
- Explain ways to prevent the spread of diseases
- Explain the importance of practising healthy habits
- Explain the meaning of the terms immunization and vaccination
- Name some common vaccines and identify the illnesses they cure

Key Stage 3

- Explain how the human immune system responds to infectious diseases

Topic: Cells

Sub-topic: Cell Structure and Function

Key Stage 3

- State that all living things are made of cells, which are the basic unit of life
- Explain the functions of the basic structures of the cell
- Use light microscope to observe, and record cell structures
- Recognise that genes are found within the nucleus of a cell that control the traits of humans and are passed from parents to children
- Explain that the body functions efficiently by having different types of cells performing specific functions (bone cells, red blood cells, muscle cells, sperm cells, egg cells)

Sub-topic: Animal Cells and Plant Cells

Key Stage 3

- Label structures of typical plant cells and animal cells
- Describe similarities and differences between plant and animal cells
- Explain the functions of main structures of plant and animal cells

Sub-topic: Characteristics of Unicellular and Multicellular Organisms

Key Stage 3

- Observe and describe the shapes and characteristics of unicellular and multicellular organisms
- Describe the structural adaptations of some unicellular organisms

Sub-topic: Cell Organisation

Key Stage 3

- Explain the hierarchical organisation of multicellular organisms
- Appreciate the wonders of our bodies where many different types of cells work together effectively

Sub-topic: Diffusion and Osmosis in Cells

Key Stage 3

- Explain the terms osmosis, diffusion and cell membrane
- Investigate and explain the processes by which substances move through cells by diffusion and osmosis

Topic: Biotechnology

Sub-topic: Application of Biotechnology Involving Microorganisms

Key Stage 3

- Explain the uses of microorganisms in developing useful products
- Cite some examples of genetic manipulation of microorganisms to produce useful products

Sub-topic: Application of Biotechnology in Human Beings

Key Stage 3

- Cite some applications of DNA technology in the human body and organ systems

Sub-topic: Application of Biotechnology in Animal and Plant Reproduction

Key Stage 3

- Explain the principles and effects of biotechnology applications in animal breeding, livestock improvement and increased productivity, and apply the knowledge
- Explain the principles and effects of biotechnology applications in propagation, variety improvement and increased productivity of crops, and apply the knowledge
- Cite some examples of DNA technology in animals and plants to improve productivity and produce useful products

Chapter 8

Material World

Strand Description

This strand aims to develop understanding of scientific concepts and principles related to material world. The content of this strand reflects on fundamental knowledge of matter as a Big Idea including states of matter, composition of matter, classification of matter, water as matter, solutions and suspensions, mixtures, acids and alkalis, chemical reactions, aqueous solutions and ions.

Matter is anything that has mass and occupies space. Matter comprises atom, molecules and ions. The basic component of matter is further classified into elements, compounds and mixtures. Different types of materials that we use in our daily lives are made from matter of different composition. These materials have different properties. It is important to relate knowledge of the properties of materials to their everyday use.

In carrying out scientific activities, students are expected to engage collaboratively with other peers to develop interest and inculcate positive values about scientific learning. The use of challenging activities should encourage the development of higher order thinking and deep understanding of the science introduced. Students should be encouraged to solve real-world problems. Students should develop own ideas from hands-on experience including the use of scientific models. This can be achieved through the use of appropriate ICT and other representations. The use of scientific activities should encourage students to take responsibility for their learning and develop confidence and informed decision.

Topic: Matter

Sub-topic: States and Properties of Matter

Key Stage 1

- Observe and identify apparent characteristics or properties of materials used in daily life
- Identify materials and compare their properties such as in toys and other common objects
- Classify types and properties of materials that are components of toys and common objects

Key Stage 2

- State that an object which has mass and occupies space is matter
- Classify objects/materials collected from daily life into solid, liquid and gas based on their physical properties
- Conduct investigations using different types of materials
- Explain the utilisation of each kind of material
- Create a product using natural materials based on knowledge of the properties of materials

Key Stage 3

- Compare and relate the properties of the three states of matter (solid, liquid and gas) in terms of arrangement, movement and energy content of the particles

Sub-topic: Particle Theory of Matter

Key Stage 3

- State that matter consists of three types of particles: atoms, molecules and ions
- Describe that matter is made up of tiny and discrete particles which are in constant and random motion
- Explain diffusion in solids, liquids and gases in terms of movement of particles

Sub-topic: Solids Float or Sink in Liquids

Key Stage 1

- Observe different kinds of solids that float and sink in liquids
- Identify objects that float and sink through investigation and record the results

Key Stage 2

- Explain the properties of materials that have the ability to float or sink
- Demonstrate methods of grouping different materials based on their ability to absorb water; their ability to float or sink; and whether they are decaying or non-decaying
- Modify objects that had sunk to float and objects that had floated to sink
- Describe density

Sub-topic: Changes in State of Matter

Key Stage 2

- Demonstrate that matter can be changed from one state to another

Key Stage 3

- Carry out investigations to observe the changes in the state of matter
- Observe similarities and differences in physical change including density differences between solids, liquids and gases through experimentation
- Explain that temperature remains constant during freezing, melting, and boiling
- Explain the interconversion of the state of matter in terms of melting, freezing boiling, evaporation, condensation and sublimation
- Describe the Law of Conservation of Mass
- Carry out investigations on physical and chemical changes of matter
- Explain the difference between physical changes and chemical changes
- Give examples of useful chemical reactions and use word equations to represent the reactions

Sub-topic: Effects of Forces, Heating and Cooling on Materials

Key Stage 2

- Conduct experiments and explain the effects of changes of materials when subjected to forces or heating and cooling
- Conduct experiments to demonstrate the effects of water and force on different materials
- Identify reversible changes in matter
- Conduct an activity to observe the irreversible changes in matter (burning and rusting)

Key Stage 3

- Explain the interconversion of the state of matter in terms of bonding and forces

Sub-topic: Harmful and Beneficial Effects of Changes in Materials

Key Stage 3

- Discuss potentially beneficial and harmful consequences of changes of materials
- Explain the changes of substances that affect living things and the environment
- Describe the Big Ideas based on the knowledge of materials

Topic: Composition of Matter

Sub-topic: Elements, Compounds and Mixtures

Key Stage 3

- Describe the properties of elements, compounds and mixtures

Topic: Classification of Matter

Sub-topic: Overview of the Periodic Table of Elements

Key Stage 3

- Explain the arrangement of elements in the Periodics Table

Sub-topic: Metals, Non-metals and Metalloids

Key Stage 3

- Classify elements as metals, non-metals and metalloids based on their physical properties

Sub-topic: Glass, Ceramics, Plastics and Fibres

Key Stage 3

- Classify a number of common everyday materials based on their properties
- Use data on the properties of different materials to make evaluative judgments about their uses
- Appreciate the existence and uses of various substances with different properties

Topic: Water as Matter

Sub-topic: Water Cycle

Key Stage 2

- Investigate and explain the processes in the water cycle

Key Stage 3

- Investigate the processes of evaporation and condensation
- Relate the changes in the state of water with the formation of clouds and rain
- Give examples of natural phenomena related to the water cycle

Sub-topic: Impact of Water Pollution

Key Stage 3

- Describe the impact of water pollution on the Earth's water resources

Sub-topic: Importance of Water Cycle in Life Processes

Key Stage 3

- Elaborate on the importance of maintaining the cleanliness of water resources
- Describe the uses of water in homes and industries

Sub-topic: Conservation of Water and Water Purification

Key Stage 3

- Explore and explain ways of water conservation and the preservation of water quality
- Show appreciation that water is a precious resource and instil awareness of water conservation
- Perform methods of water purification and preservation of water quality

Sub-topic: Solutions, Mixtures and Suspensions

Key Stage 3

- Distinguish between solute, solvent and solution
- Differentiate the solids which are soluble and insoluble in water
- Understand that some gases can also dissolve in water to form a solution
- Classify mixtures into solutions, colloids and suspensions
- Conduct simple experiments on solutions and suspensions

Sub-topic: Factors Affecting Solubility and Rate of Dissolving Substances

Key Stage 3

- Investigate the factors that affect the quantity of solid that dissolves in water
- Investigate the factors that affect the solubility and rate of dissolving substances

Sub-topic: Separation Technique

Key Stage 3

- Use separation techniques such as filtration, distillation and paper chromatography to separate mixtures and show awareness of the basic principles involved
- Select appropriate techniques for separating constituents of mixtures
- Interpret a chromatogram in terms of the number of different dyes present
- Explain the techniques involved in obtaining pure water from sea water in desalination plants

Topic: Acids, Bases and Salts

Sub-topic: Properties of Acids, Bases, and Alkalis

Key Stage 3

- Classify everyday substances as acids or bases based on their properties
- Understand that both acids and bases react with indicators to produce different colours
- Conduct an activity to investigate the properties of acids and alkalis in terms of:
  - pH value
  - effect on litmus paper
- Investigate the effects of acids, alkalis and neutral solutions on:
  - Red/Blue Litmus paper
  - pH paper
  - Universal Indicator
  - Natural Indicator
- Prepare natural indicators (obtained from plants) as an acid-base indicator
- List some common acids and bases used at home and in industry

Sub-topic: Neutralisation

Key Stage 3

- Recognise that acids and bases neutralise each other
- Define neutralisation as a chemical reaction where an acid and an alkali react to form salt and water only
- Write a word equation for neutralisation
- Write simple equation for neutralisation
- Describe neutralisation in daily life

Topic: Chemical Reactions

Sub-topic: Chemical Change

Key Stage 3

- Understand different types of chemical reactions
- Understand chemical reactions that occur in the presence of light (e.g. photosynthesis)

Sub-topic: Chemical Compounds

Key Stage 3

- Classify different types of compounds (ionic or covalent) from their physical properties like melting point, hardness, polarity, electrical and thermal conductivity
- List names of organic compounds and their uses

Topic: Aqueous Solutions and Ions

Sub-topic: Electrolysis

Key Stage 3

- Understand electrolysis of aqueous solutions
- Identify electrolyte and non-electrolyte
- Conduct an experiment on electrolysis of water
- Explain the importance of electrolysis in daily life and industries

Sub-topic: Chemical Cells

Key Stage 3

- Understand chemical cells
- Conduct a simple experiment to understand the production of electrical energy from chemical reactions
- Appreciate the innovative efforts in the design of equipment using chemical reactions as source of energy

Chapter 9

Energy and Change

Strand Description

This strand aims to develop understanding of scientific concepts and principles related to the big idea of energy. It includes energy changes and transfers, energy calculation of fuel uses and costs, energy changes in systems, observed waves, sound waves, energy and waves, light waves, use of lenses, heat, stability, forces, motion, pressure in fluids, balanced forces, simple machines, current electricity, static electricity, magnetism, electromagnetism, particle model of matter, energy in matter, space and nuclear physics.

In carrying out scientific activities, students are expected to engage collaboratively with other peers to develop interest and inculcate positive values about scientific learning. The use of challenging activities should encourage the development of higher order thinking and deep understanding of the science introduced. Students should be encouraged to solve real-world problems. Students should develop own ideas from hands-on experience including the use of scientific models. This can be achieved through the use of appropriate ICT and other representations. The use of scientific activities should encourage students to take responsibility for their learning and develop confidence and informed decision making relating to energy sources, energy transformations and conservation.

Topic: Sound

Sub-topic: Sources, Properties, Harmful Effects of Loud Sound, Hearing Sound Waves

Key Stage 1

- Identify the sources of sound
- Differentiate sources of sound in terms of loudness and tone
- Appreciate the need to avoid harmful effects of loud sounds

Key Stage 2

- Infer through investigation that sounds are produced due to a vibrating source
- Infer through investigation that sound needs a medium through which to travel
- Discuss the harmful effects of loud sounds

Key Stage 3

- Explain that sounds are produced due to interactions between particles of a medium caused by a vibrating source
- Explain the generation of sound waves, sound intensity, hearing, and sound quality, and apply the knowledge
- Differentiate the properties of sound in terms of pitch, volume, and amplitude
- Relate the pitch of a sound to its frequency, and loudness to its amplitude
- Investigate the effect of different materials on the transmission of sound
- Explain how the ear detects sounds in terms of the vibrations of the eardrum and ear bones, and the subsequent interpretation of sound by the brain
- Recognise how the property of sound waves can be used to explain common real-life phenomena

Topic: Light

Sub-topic: Sources, Properties /Characteristics, Behaviour of Light on Materials, How We See Things

Key Stage 1

- List the various sources of light
- Demonstrate the formation of shadows

Key Stage 2

- Demonstrate that light travels in straight line
- Differentiate the characteristics of 'transparent',' translucent' and 'opaque' materials
- Investigate the variables that affect shadow formation

Key Stage 3

- Describe different properties and characteristics of light
- Show an understanding that the ray model represents the path taken by light
- Explain how a person sees things
- Relate how light affects the behaviour of humans and other living things

Sub-topic: Reflection

Key Stage 1

- Find out that light reflects on the mirror

Key Stage 2

- Identify examples of reflection of light observable in daily life

Key Stage 3

- Explain how reflection is affected by a smooth and rough surface
- Investigate the characteristics of the image formed by a plane mirror
- Apply the properties of reflection of light for everyday uses (e.g. plane and curved surfaces)

Sub-topic: Refraction and Lenses

Key Stage 2

- Define the meaning of refraction
- Identify examples of refraction of light observable in daily life

Key Stage 3

- Investigate the effects of refraction of light
- Explain refraction in terms of the speed of light in a medium
- Apply ray diagrams to describe the characteristics and positions of the image formed by lenses
- Compare images formed by different types of lenses (e.g. convex and concave lenses)
- State the uses/benefits of convex and concave lenses
- Appreciate the benefits of optical instruments to daily life and for the advancement of society (e.g. eyeglasses, mirrors, binoculars, telescopes and microscopes)

Sub-topic: Colours of Light

Key Stage 2

- Investigate the component colours of white light
- Describe the dispersion of white light by a prism

Key Stage 3

- Analyse dispersion of light
- Experiment and explain absorption of coloured light, colour vision, and apply the knowledge
- Analyse the principle of subtraction of colour of light to explain the appearance of coloured objects
- Explain how we see the colour of objects in white light and coloured light such as red, blue and green
- Appreciate the importance of colour in daily life

Sub-topic: Light Intensity and Colour

Key Stage 3

- Demonstrate an understanding of the characteristics of light intensity or brightness and colour
- Explain the effects of brightness of light on humans and other living things

Topic: Waves

Sub-topic: Properties of Mechanical Waves

Key Stage 3

- Describe what is meant by wave motion as illustrated by vibrations in ropes and springs and by waves in a ripple tank
- Explain the relationship between speed, frequency and wavelength of mechanical waves
- Compare transverse and longitudinal waves and give suitable examples of each

Sub-topic: Electromagnetic Waves

Key Stage 3

- Demonstrate an understanding that all electromagnetic waves are transverse waves that travel with the same speed in vacuum
- Describe the main components of the electromagnetic (EM) spectrum
- Explain the benefits and the harmful effects of EM radiation on living cells and tissues

Topic: Electricity

Sub-topic: Sources, Conductors, Insulators, Circuits, and Electrical System

Key Stage 1

- Identify the various sources of electricity
- Differentiate between closed/complete and open/incomplete circuits
- Differentiate between electrical conductors and insulators

Key Stage 2

- Analyse the direction of electric current
- Differentiate between series and parallel circuits
- Recognise the components of an electrical system which consists of an energy source and other circuit components
- Investigate how different brightness of light bulbs and volume of sounds are produced by using different number and arrangement of batteries

Key Stage 3

- Associate the symbols with the respective components of an electrical circuit
- Draw and interpret circuit diagrams and set up circuits containing electrical sources, switches, lamps, resistors (fixed and variable), ammeters and voltmeters
- Set up simple electric circuits in series and parallel
- Describe the function of diode, transistor and capacitor
- Set up a working electric circuit consisting of diode, transistor or capacitor

Sub-topic: Current, Voltage and Resistance

Key Stage 3

- State that electric current is the flow of electrons
- State that ampere (A) and volt (V) are the units of current and voltage respectively
- Investigate the relationships between current, voltage and resistance in series circuits
- Investigate the relationship between current, voltage and resistance in parallel circuits
- Recognise that the resistance of a circuit can be varied by arranging resistors in series or parallel

Sub-topic: Electrical Hazards, Safety Precautions and Devices at Home

Key Stage 1

- Name different types of electrical appliances
- Recognise the need for safety precautions when handling electrical appliances

Key Stage 2

- Recognise the need to conserve electricity (e.g. by using more energy-efficient appliances)
- Practise safe and economical connection of household electrical circuits

Key Stage 3

- Explain the importance of a fuse, circuit breaker and grounding in the safe use of electrical appliances

Sub-topic: Power and Electrical Energy

Key Stage 2

- Identify through experimentation the conversion of electrical energy to other forms of energy
- Analyse how the amount of electrical energy affects heat, brightness of light or volume of sound produced
- Identify through experimentation the different electrical appliances and the energy output in them
- Identify ways by which energy is used wisely

Key Stage 3

- Explain the meaning of power and its unit
- Explain electrical energy using the concept of power (e.g. by comparing power ratings of different electrical appliances)
- Analyse the cost of electrical usage
- Calculate electrical energy consumption of electrical appliances
- Describe how electricity is generated and distributed from the generating plant to household users
- Cite the importance of distribution grids in the transmission of electricity
- Justify the need to conserve electrical energy
- Practise the conservation of electrical energy

Sub-topic: Static Electricity

Key Stage 1

- Produce electrical forces by rubbing two objects together

Key Stage 2

- Differentiate static from current electricity

Key Stage 3

- Explain how static electricity is formed using the concept of charges
- Apply Coulomb's Law in describing the amount of electrical forces between charges

Topic: Magnetism

Sub-topic: Properties of Magnets/Magnetic Field and Electromagnets

Key Stage 1

- Differentiate between magnetic and non-magnetic materials
- Demonstrate the properties of magnetic attraction and repulsion
- Compare the strength of different types of magnets
- Recognise simple applications of magnets in daily life

Key Stage 2

- Investigate the properties of a magnet
- Investigate the relationship between strength of the magnetic force and the distance from a magnet or magnets of different sizes
- Observe and draw magnetic field patterns using iron filings around a magnet
- Create a magnet using the stroke or electrical method
- Create simple toys using the properties of magnets to serve a particular purpose

Key Stage 3

- Infer through experimentation that a current carrying wire produces a magnetic field around it
- Analyse the magnetic field around an electromagnet
- Investigate the factors affecting the strength of an electromagnet
- Construct a simple DC motor
- Investigate and discuss the factors affecting the strength of the turning effect of a motor
- Describe the design of a simple generator
- Recognise the applications of electromagnets in daily life

Topic: Force and Motion

Sub-topic: Forces and Their Effects

Key Stage 1

- Demonstrate the effect of different forces on an object and its motion
- Differentiate the different types and strengths of forces (e.g. squashing, bending, twisting and stretching) and their effects on objects

Key Stage 2

- Classify forces as contact and noncontact
- Carry out an experiment and describe the effects of forces
  - On the state of rest or motion of a body
  - On the size of a body
- Identify some examples of forces, including gravitational force, frictional force, magnetic force and predict their effects on an object
- Use the Newton as the SI unit of force
- Cite the effects of varying amounts of force to the speed of an object

Key Stage 3

- Identify the relationship between force, mass and acceleration of an object
- Perform investigations that show the effect of the varying amounts of force on the acceleration of an object
- Determine the magnitude and direction of the resultant force of several co-planar forces acting in an object
- Experiment and explain static and kinetic frictions and relationships between frictional force and characteristics of contact surfaces and reaction force perpendicular to the surfaces
- Apply knowledge of frictional force in daily life
- Identify action-reaction pairs in a system
- Experiment and explain action and reaction forces, and apply the knowledge
- Demonstrate understanding of Newton's three laws of motion through experiments
- Solve real life problems by applying knowledge and understanding of Newton's laws of motion

Sub-topic: Distance/Time, Displacement, Speed/Velocity, and Acceleration

Key Stage 1

- Measure the distance travelled by an object

Key Stage 2

- Explain the motion of an object using speed, distance and time
- State the relationships between distance, speed and time
- Perform activities that describe the motion of an object
- Measure the period of pendulum
- Experiment and explain distance, speed, displacement and velocity of objects in motion

Key Stage 3

- Differentiate quantities using concepts of distance vs. displacement, speed vs. velocity and acceleration
- Explain acceleration and effects of a resultant force acting on an object
- Give daily life examples of force, mass, acceleration, work and force
- Solve real-life problems by applying knowledge and understanding of distance, time, speed, velocity and acceleration

Sub-topic: Inertia/Momentum

Key Stage 3

- Demonstrate understanding of projectile motion, impulse, momentum and conservation of momentum
- Cite examples that obey the law of conservation of momentum
- Determine the factors that affect the value of momentum of a body
- Apply the concepts of momentum
- Explain the concept of inertia

Sub-topic: Simple Machines and Moment of Force

Key Stage 2

- Demonstrate and explain how levers , pulleys, gears, and inclined planes work
- Analyse levers through investigation
- Explain the condition for a lever in a balanced state in relation to the moment of force
- Calculate the moment of a force using the equation: moment of a force about a point = force x perpendicular distance from the pivot to the line of action of the force
- List uses of levers, pulleys, gears, and inclined planes in daily life

Key Stage 3

- Identify the different classes of levers
- Determine through experimentation the mechanical advantage of different simple machines
- Explain what is meant by moment of a force
- Appreciate the innovative efforts in the design of simple machines to simplify work
- Define centre of gravity
- Investigate how the centre of gravity affects stability
- Identify the different types of equilibrium based on the location of the centre of gravity
- Appreciate the importance of stability in real life situations

Topic: Pressure

Sub-topic: Relate Pressure to Force and Area

Key Stage 3

- Explain the relationship of force, pressure and area
- Calculate pressure using the equation: pressure = force/area
- State that the SI unit of pressure is Newton per square meter or Pascal (Pa)
- Describe examples of daily life phenomena related to pressure

Sub-topic: Fluid Pressure

Key Stage 3

- Perform experiments that identify the factors affecting liquid pressure
- Measure atmospheric pressure using appropriate instruments
- Relate the value of atmospheric pressure to altitude
- Describe examples of daily life phenomena associated with atmospheric pressure

Sub-topic: Hydraulic System in Daily Life

Key Stage 3

- Explain Pascal's principle
- Describe and explain the transmission of pressure in hydraulic systems
- Cite examples of equipment that use hydraulic systems in everyday life
- Apply the principle of hydraulic systems in everyday life

Sub-topic: Buoyant Force of Liquid

Key Stage 3

- Explain the buoyant force of a liquid acting upon objects
- Define the buoyant force and relate it to Archimedes' Principle
- Carry out experiment and describe the design of ships and submarines in terms of buoyant force

Topic: Energy, Work and Power

Sub-topic: Common Forms, Sources, Uses of Energy, and Renewable and Non-Renewable Energy

Key Stage 1

- Recognise that the Sun is the primary source of light and heat energy
- Investigate the movement of an object which is moved by wind, water flow, falling object or rubber

Key Stage 2

- Identify the common sources and uses of energy
- Describe different forms of energy (e.g. sound, light, heat, kinetic, potential, electrical, etc.)

Key Stage 3

- Identify the various forms of potential energy (e.g. gravitational, elastic, electrical)
- Differentiate between kinetic energy and potential energy
- Identify renewable and non-renewable sources of energy
- Evaluate the benefits and risks when using various sources of energy (e.g. geothermal, biofuels, fossil fuels, solar, hydro-electric, wind, nuclear) to generate electricity and consider their impact to the environment

Sub-topic: Conversion of Energy, Law of Energy Conservation

Key Stage 2

- Investigate and explain energy conversion from one form to another
- Identify the energy conversions in everyday household appliances

Key Stage 3

- Investigate and explain that energy can be transformed from one form to another, taking reference to the law of energy conservation, to various situations (e.g. pendulums, balls on an inclined plane)
- Recognise energy losses in mechanical systems due to friction
- Perform mathematical calculations involving conversion of energy
- Design and perform investigations that demonstrates the law of conservation of energy

Sub-topic: Work and Power

Key Stage 3

- State joule as the unit of energy
- State that energy is the capacity to do work
- Identify the unit of work as the joule (J)
- Show an understanding that work is done when an object moves in the same direction as the applied force
- Compare between situations involving forces where work is done and where work is not done
- Carry out an experiment and calculate work done by a force using: work done = force x distance moved in the direction of the force

- Show an understanding of power as the rate at which work is done
- Establish the relationship between force, distance, work, energy and power

Topic: Heat

Sub-topic: Heat-Temperature Relationship

Key Stage 1

- Identify sources of heat in daily life
- Demonstrate the ways of producing heat

Key Stage 2

- State heat as a form of energy
- State that temperature of an object is a measurement of the degree of hotness or coldness of the object
- Differentiate between heat and temperature
- Use a thermometer to measure temperature
- Identify different units of temperature and convert temperature measurements from one unit to another
- Infer that heating an object can increase its temperature

Key Stage 3

- Identify the effects of heat gain/loss in everyday life (e.g. change of state of matter, contraction and expansion of objects)

Sub-topic: Conduction, Convection and Radiation

Key Stage 2

- Demonstrate that heat can be transferred from one object to another
- Carry out an experiment to show an understanding that heat flows from a hotter to a colder object or region until both reach the same temperature
- Investigate the difference of heat transfer between solid and fluid

Key Stage 3

- Investigate and explain heat transfer by conduction, convection and radiation
- Identify and explain applications of heat conduction, convection and radiation (e.g. in cooling, heating, insulation and solar radiation) in daily life

- Deduce from experiments that different materials have different rates of heat flow
- Investigate the factors affecting the rate of heat loss or gain by a body through radiation (e.g. nature of the surface)
- Solve real world problems through the application of knowledge and understanding of conduction, convection and radiation

Sub-topic: Thermal Expansion and Contraction

Key Stage 2

- Investigate the effect of heat on the expansion and contraction of matter

Key Stage 3

- Infer from experimentation that generally, solids, liquids and gases expand when heat is absorbed and contract when heat is given off
- Infer from experimentation that thermal expansion results in a change in volume of the substance and therefore the density of the substance
- Deduce from experiments that different materials have different values of specific heat capacities
- Explain the effects of expansion and contraction of matter in everyday situations

Topic: Nuclear Physics

Sub-topic: Radiation

Key Stage 3

- Explain the types and properties of radiation from radioactive elements
- Cite applications of radiation in industry, medicine and radioactive dating
- Explain the cause of radioactivity and identify methods for detection of radiation in the environment, their applications, and effects on living things and the environment
- Be made aware of the need for proper handling of radioactive substance

Sub-topic: Atomic Structure

Key Stage 3

- Understand the structure of an atom
- Apply the idea of proton number and nucleon number in atoms of elements
- Relate that atoms and molecules in matter are in constant motion and the differences in relative motion and distance between particles in solids, liquids and gases
- Apply knowledge about the movement of and distance between atoms and molecules to explain the physical properties of solids, liquids, and gases (volume, shape, density and compressibility)

Sub-topic: Nuclear Reaction, Nuclear Power and Its Uses

Key Stage 3

- Explain nuclear reaction, fission, fusion and the relationship between mass and energy
- Carry out research and discuss outcomes of research about nuclear power plants, and apply the knowledge
- Describe the process how a nuclear power plant generates electricity
- Express ideas, opinions or viewpoints on the pros and cons of generating electricity through nuclear power plants
- Search for information on energy generated from nuclear reactions and its effects on living organisms and the environment

Chapter 10

Earth and Space

Strand Description

This strand encompasses the topics of soil, water, atmosphere, weather and climate, earthquakes and volcanic eruptions, Earth, solar system and universe and space technology. Through scientific activities, it is expected that students will develop creative and critical thinking skills, creativity, collaboration, teamwork, communication skills and ICT skills. It is also expected that students will be engaged in applying, modelling and exemplifying.

In carrying out scientific activities, students are expected to engage collaboratively with other peers to develop interest and inculcate positive values about scientific learning. The use of challenging activities should encourage the development of higher order thinking and deep understanding of the science introduced. Students should be encouraged to solve real-world problems. Students should develop own ideas from hands-on experience including the use of scientific models. This can be achieved through the use of appropriate ICT and other representations. The use of scientific activities should encourage students to take responsibility for their learning and develop confidence and informed decision.

Topic: Soil

Sub-topic: Soil and Growth of Plants

Key Stage 1

- Identify through experimentation the different types of soil, such as clay, garden soil and sand

Key Stage 2

- Explore and classify soil using physical properties as criteria, and apply the knowledge
- Investigate and sequence the types of soil based on the ability for water to flow through them
- Explore, experiment and explain the components and physical properties of soil in the local area
- Determine different types of soil to support different types of plants through observation using multiple media

Key Stage 3

- Identify common sources of soil pollution and action taken to reduce soil pollution
- Conduct a local investigation on the different types of soil and the vegetation that thrive in them

Topic: Water

Sub-topic: Water Resources, State of Water and the Environment

Key Stage 1

- Identify the natural water resources

Key Stage 2

- Explore and explain the physical properties of water from sources in the local area
- Explain the importance of water in daily activities
- Identify common sources of water pollution and action taken to reduce water pollution
- Describe the impact of water pollution on Earth's water resources
- Understand the water supply system

Key Stage 3

- Design a water supply system model

Topic: Solid Earth

Sub-topic: Physical Structure, Components and Layers of Earth

Key Stage 2

- Describe the different layers of the Earth
- Identify and describe the different land forms

Key Stage 3

- Illustrate how some human activities affect ecosystems
- Recognise that soil, water, rocks, coal and other fossil fuels are Earth materials
- Recognise that Earth materials provide many of our resource
- Identify and describe common Earth materials and explain their composition, origin and uses

Sub-topic: Plate Tectonic Theory

Key Stage 3

- Discuss the theory of plate tectonics
- Identify the different evidences that can be used to understand the movement of the lithospheric plates over geological time
- Demonstrate the mechanisms of crustal growth and transfer of heat at spreading ocean ridges
- Discuss the difference between relative and true plate motion
- Relate plate tectonics theory to seafloor spreading
- Describe and locate fault lines in the graphs of the 'Pacific Rim of Fire' using models or illustrations
- Explain how movement along faults generate earthquakes

Sub-topic: Earth's Processes, Cycles and Geological Events

Key Stage 2

- Define weathering and erosion and identify the different factors affecting them
- Describe how weathering and erosion help shape the surface of the earth

Key Stage 3

- Describe the fundamental Earth systems and cycles including how they integrate sub-disciplines and cross traditional discipline boundaries and explain how they truly benefit society
- Explain the processes operating at and beneath the Earth's surface, how those processes create the Earth's landscape, and how humans affect and are affected by the processes
- Discuss and demonstrate the geological processes, and interactions between the various physical and biological components of the Earth system
- Discuss and explain the Earth system relating to mining and management of Earth's resources
- Research and discuss and describe the geologic time and major events in the evolution of Earth
- Analyse, interpret and report on laboratory and field findings using appropriate statistical techniques and computer applications
- Discuss how geological processes cause changes in the geomorphology of the Earth's surface

Topic: Atmosphere

Sub-topic: Layers of Earth's Atmosphere and Important Gases

Key Stage 2

- Identify and describe the different elements of weather (temperature, pressure, humidity, precipitation, wind systems, etc.)

Key Stage 3

- Describe the different layers of the atmosphere
- Describe how different weather systems affect the land and sea and how land and sea affect weather systems
- Show how waves are generated by wind events, and the principles that govern wave energy propagation, and of the transformation/dissipation of waves in the coastal zone
- Illustrate how human activities affect the atmosphere and the build-up of greenhouse gases (GHGs)
- Discuss and explain how energy from the Sun enters the atmosphere and how the atmospheric gases react and transform
- Interpret and explain how global temperature affects the atmospheric gases and alter the atmospheric functionalities
- Research and explain the effect of sea temperature focusing on El Nino and La Nina phenomenon

Sub-topic: Changes in Atmospheric Conditions

Key Stage 3

- Research, discuss and explain how the atmosphere protects and maintains global temperature to maintain life forms in the ecosystem
- Interpret and explain how solar radiation heats up the Earth's surface and influence the changes in atmospheric structure

Topic: Weather and Climate

Sub-topic 1: Weather Disturbances and Safety Measures

Key Stage 1

- Observe, record and describe patterns of daily weather at different times of the day

Key Stage 2

- Observe, identify and describe different kinds of weather
- Explain the difference between the terms "weather" and "climate"

Key Stage 3

- Demonstrates understanding of the types of weather, characteristics of weather changes and how these relate to daily activities, health and safety
- Explain the different weather disturbances such as storm and typhoons
- Give reasons for the occurrence of the intertropical convergence zones
- Explain how landforms and bodies of water affect typhoons
- Trace the path of typhoons using topographic maps and tracing data
- Identify and explain the different technological advancement in the analysis and prediction of weather
- Make suggestions with regard precautions and actions that communities could take in preparation for weather disturbances such as storms and typhoons

Sub-topic: Weather Phenomena Affect Humans and Living Things

Key Stage 3

- Observe, analyse, and discuss weather phenomena affecting humans
- Understand the different weather disturbances such as storm and typhoons
- Research, analyse and explain effects of the weather on the communities and the environment
- Research, analyse and explain the natural factors and human actions affecting changes of the Earth's temperature, ozone holes, and acid rain
- Discuss how human activities contribute to or reduce ozone depletion and global warming
- Suggest solutions to problems associated with pollution, global warming, and water resources

Sub-topic: Seasons

Key Stage 1

- Through observation give examples of seasonal weather changes
- Identify and explain the type of clothing that is appropriate to wear during different seasons

Key Stage 2

- Compare pictures of the different seasons
- Discuss experiences and knowledge of the different seasons
- Demonstrate by using simple models to show that movement and tilt of Earth produce seasons

Key Stage 3

- Use models to explain the effects of the following:
  - the tilt of the Earth on the length of daytime
  - the length of daytime to the amount of energy received
  - the position of the Earth in its orbit to the height of the Sun in the sky
  - the tilt and movement of the Earth to the height of the Sun in the sky
  - the height of the Sun in the sky to the amount of energy received
  - the latitude of an area to the amount of energy the area received

Sub-topic: Effects of Seasons on Livelihood and Human Health

Key Stage 1

- Explain the effects of seasons to human health

Key Stage 2

- Describe the seasons and their effects on livelihood and the health of people in the community

Key Stage 3

- Discuss the different government programmes that mitigate the effect of changing seasonal weather conditions to economy and human health

Topic: Faults, Volcanic Eruptions, Earthquakes and Disaster Management

Sub-topic: Faults

Key Stage 3

- Use models and illustrations to explain how movements along faults generate earthquakes and form mountains

Sub-topic: Volcanic Eruptions and Warning Signs

Key Stage 2

- Describe the different volcanic structures and eruptive styles
- Characterize the different materials extruded during volcanic eruptions
- Describe common warning signs that a volcano is about to erupt
- Identify volcanic hazards
- Describe different volcanic monitoring activities
- Make an emergency plan with the family for earthquakes, tsunami and volcanic eruptions

Key Stage 3

- Use models and illustrations to explain how volcanoes erupt
- Illustrate different types of volcanism at different plate boundaries

Sub-topic: Earthquakes

Key Stage 3

- Differentiate the epicenter of an earthquake from its focus
- Differentiate types of earthquake waves
- Discuss and explain how the process by which the epicenter of an earthquake is located
- Discuss and explain how tsunami relates to an earthquake
- Differentiate the intensity of an earthquake from its magnitude

Sub-topic: Disaster Preparedness during Earthquakes, Tsunamis and Volcanic Eruptions

Key Stage 2

- Understand and explain the disaster safety precautions taken before, during and after earthquakes, tsunamis and volcanic eruptions
- Make informed decisions about what safety precautions to take before, during and after earthquakes, tsunamis and volcanic eruptions

Key Stage 3

- Be aware and participate in disaster management activities

Topic: Earth, Solar System and the Universe

Sub-topic: Earth as a Member of the Solar System and the Universe

Key Stage 1

- State that there are the Sun, the Moon and the stars in the sky
- Observe, describe and ask questions about movement of the Sun
- Observe, describe and ask questions about the changes in temperature on different times of the day
- State that the Sun is a star and explain its importance
- Demonstrate understanding of the benefits as well as harmful effects of the Sun
- State that planets rotate on their own axis and at the same time revolve around the Sun at their own orbit through observation from various media
- Draw diagrams to show the orbit of the planets around the Sun
- State that the Sun, Earth, planets and satellites are part of the Solar System

Key Stage 2

- Estimate the relative distance of Earth to Sun compared to the relative distance of Earth to Moon
- Describe that Moon does not emit light but reflects Sun's light
- Describe and explain that the Earth rotates and revolves in aspects of direction and time by carrying out simulations
- Observe and explain that rotation of the Earth causes the rising and setting of the Sun and the Moon and the occurrence of days and nights

- Construct a simple model to show the rotation of the Earth
- Explain the events of day and night through simulation
- Observe and explain that Moon appears to have in different shapes at different periods of the month
- Differentiate size and the relative distance between Earth, Moon and Sun
- List the planets of the Solar System and their location
- Construct a model of the Solar system
- State that a constellation is a group of stars that form a certain pattern
- Locate and identify shapes of constellations such as Big Dipper, Southern Cross, Scorpion, Orion
- Describe lunar and solar eclipse phenomena with the assistance of sketches based on the position of the Moon, Earth and Sun and the properties of light

Key Stage 3

- Differentiate an asterism from a constellation and identify examples
- Explain the use of constellations to indicate directions and indicate seasons
- Explain how tides are affected by the positions of Earth, Moon and Sun
- Understand the physical characteristics of the planets of the Solar System
- Compare and contrast comets, meteors and asteroids
- Predict the appearance of comets based on recorded data of previous appearances
- Explain the regular occurrence of meteor showers

Topic: Space Technology

Sub-topic: Advancement and Benefits of Space Technology

Key Stage 2

- Research, discuss and present the understanding of the advancement and benefits of space technology

Key Stage 3

- Research (including ICT), discuss and present understanding of advancement in space technology for exploration of space, celestial objects, weather conditions, agriculture, navigation, and communication
- Research (including ICT), discuss and present understanding of applications and benefits of launching rockets, satellites, space crafts and space stations

Chapter 11

Science, Engineering and Technology for a Sustainable Society

Strand Description

In order to develop a sustainable society, we need to be innovative and solve real-world problems relating to conservation of natural resources, environmental conservation, water and energy resources, pollution and wastes, health and diseases, drugs, ethical , moral and social issues in science, technology and engineering, ICT and cybercrimes. Thus this strand engages students to solve problems key measures of sustainable development and developing solutions associated with these issues. It also engages students in developing good practice with regard to sustainable development and global citizenship.

In carrying out scientific activities, students are expected to engage collaboratively with other peers to develop interest and inculcate positive values about scientific learning. The use of challenging activities should encourage the development of higher order thinking and deep understanding of the science introduced. Students should be encouraged to solve real-world problems. Students should develop own ideas from hands-on experience including the use of scientific models. This can be achieved through the use of appropriate ICT and other representations. The use of scientific activities should encourage students to take responsibility for their learning and develop confidence and informed decision.

Topic: Environment and Conservation of Natural Resources

Sub-topic: A Healthy Environment

Key Stage 1

- Share experience of good and healthy environment

Key Stage 2

- Suggest ways to maintain a healthy environment
- Practise the habit of maintaining a healthy environment

Key Stage 3

- Investigate any issues related to real life context about the environment

Sub-topic: Impact of Human Activities on the Environment

Key Stage 2

- Gather information using available resources and ICT the impact of human activities on the environment
- Discuss causes and effects of human activities on the environment
- Suggest ways to address the negative effects of human activities on the environment

Key Stage 3

- Conduct research and suggest ways to address the negative effects of human activities on the environment

Sub-topic: Impact of Modernisation on the Environment

Key Stage 2

- Suggest possible solutions to overcome the negative impact of modernisation on the society and on environment

Key Stage 3

- Debate the positive and negative impacts of modernisation on environment
- Design products related to the solution of problems associated with the impact of modernization on the environment

Sub-topic: Impact of Human Activities on Air Quality

Key Stage 2

- Analyse the composition of polluted air and the effects of various air pollutants
- Research and report on human activities which affect air quality

Key Stage 3

- Evaluate human activities affecting air quality
- Design a model to decrease the effects of air pollutants

Sub-topic: Acid Rain

Key Stage 2

- Explain the causes of acid rain
- Investigate the formation of acid rain

Key Stage 3

- Evaluate the impact of acid rain

Sub-topic: Wise Use and Consumption of Natural Resources

Key Stage 2

- Evaluate the availability of food and natural resources
- Suggest ways to optimize the use of natural resources

Key Stage 3

- Evaluate the different methods of conserving natural resources
- Innovate alternatives to natural resources

Sub-topic: Conservation of Water and Energy

Key Stage 1

- Compare the quality of drinking water from different sources

Key Stage 2

- Inculcate the awareness of water and energy shortage
- Suggest ways of conserving water and energy supply

Key Stage 3

- Conduct research and make informed decisions with regard alternative sources of water and energy

Sub-topic: Renewable and Non-Renewable Energy Sources

Key Stage 2

- Analyse renewable and non-renewable sources of energy

Key Stage 3

- Suggest different potential energy sources
- Argue with scientific evidence the advantages and disadvantages of different energy sources
- Create a low cost model for alternative energy source

Sub-topic: Green Living

Key Stage 1

- Appreciate green living in daily lives

Key Stage 2

- Practise and appreciate green living in daily lives

Key Stage 3

- Conduct research and make a presentation to illustrate evidence of green living in real life context
- Design a model to implement practical green living in real life context

Topic: Ecosystem and Environmental Management

Sub-topic: Changes in the Components of Ecosystems

Key Stage 2

- Explain population, community, habitat and ecosystem
- Differentiate the biotic and abiotic components of an ecosystem
- Survey and report on the various ecosystems in the local area

Key Stage 3

- Identify factors and natural hazards affecting the changes of population size in an ecosystem
- Gather information on how water supply, migration and population changes affect the availability of resources

Sub-topic: Environmental Conservation and Use of Technology

Key Stage 2

- List the ways and justify the importance of conservation and preservation of environment

Key Stage 3

- Design and conduct project-based activities on the importance of conservation and preservation of the environment
- Design ways to use technology to conserve the environment

Sub-topic: Responsible Attitudes in Proper Management of Natural Resources

Key Stage 2

- Cultivate responsible attitudes in the management of natural resources

Key Stage 3

- Report the management of natural resources through project-based activities
- Evaluate the management of natural resources

Sub-topic: Water, Carbon and Biogeochemical Cycles in Nature

Key Stage 3

- Illustrate and explain the process of decomposition and nutrient cycling
- Illustrate water, carbon and biogeochemical cycles in nature
- Explain the importance of the natural biogeochemical cycles in daily life

Sub-topic: Survival and Extinction of Endangered Species

Key Stage 3

- Elaborate on the survival and extinction of endangered species due to the changing environment
- Evaluate the application of technology in protecting and conserving the endangered species

Sub-topic: Effects of Noise Pollution and Electro-Magnetic Waves on Living Things

Key Stage 3

- Identify safe levels as well as the detrimental effects of noise and electromagnetic waves

Sub-topic: Management of Solid Waste, Industrial Waste and Electronic Waste

Key Stage 3

- List and evaluate the different ways to manage solid, industrial and electronic wastes
- Present/Develop arguments on the environmental problems associated with the disposal of solid, industrial and electronic wastes
- Create an event to instil awareness on managing solid, industrial and electronic wastes

Topic: Human Health and Management

Sub-topic: Awareness of Healthy Food and Diet

Key Stage 1

- Practise healthy eating habits

Key Stage 2

- Identify and justify healthy food
- Generate reasons for healthy and unhealthy food in relation to better health

Key Stage 3

- Gather information on the impact of food additives and processed food on humans
- Produce and promote healthy food and diet

Sub-topic: Exercise to Keep Fit

Key Stage 1

- Implement regular exercise

Key Stage 2

- Explain and implement a healthy lifestyle through regular exercise

Key Stage 3

- Design a programme to promote a healthy lifestyle through exercise

Sub-topic: Preventing Heart Disease, High Blood Pressure, Diabetes and Obesity

Key Stage 3

- Plan a programme/Construct precautionary steps to prevent heart disease, high blood pressure, diabetes and obesity

Sub-topic: Smoking and Lung Disease

Key Stage 2

- Recognise the harmful effects of smoking on the lungs

Key Stage 3

- Justify the harmful effects of smoking to human health
- Suggest ways of how to reduce smoking
- Create ads, posters on the harmful effects of smoking to human health

Sub-topic: Prevention against Influenza, Measles, and Malaria

Key Stage 2

- Explain the causes of influenza, measles and malaria
- Describe the symptoms of influenza, measles and malaria
- Practise healthy habits to prevent the spread of influenza, measles and malaria

Key Stage 3

- Plan project-based activities to prevent the spread of influenza, measles, and malaria

Sub-topic: Preventing Harmful Effects of STDs and Controversial Practices to the Reproductive System

Key Stage 3

- Use ICT to gather information and report on sexually transmitted diseases (STDs) and HIV-AIDS
- Critique the harmful consequences of STDs and HIV-AIDS
- Describe how to prevent the spread of STDs and HIV-AIDS
- Develop arguments on the issues relating to controversial practices of abortion and pre-marital sex

Sub-topic: Impact of Drug/Substance Abuse and Solvents Including Alcohol on Humans and Society

Key Stage 3

- Use ICT to gather information relating to drug/substance abuse and solvents including alcohol on humans and society
- Explain and justify the impact of drug/substance abuse and solvents including alcohol on humans and society

Topic: Scientific, Technological and Engineering Breakthrough

Sub-Topic: Role of Science, Technology and Engineering to Improve the Quality of Life

Key Stage 1

- List current technological gadgets

Key Stage 2

- Examine the role of science, technology and engineering as a tool to improve the quality of life
- Evaluate the application of science, technology and engineering to help improve the quality of life
- Appreciate scientific, technological and engineering advancements

Key Stage 3

- Design a product using technology to improve the quality of life

Sub-topic: Ethical, Moral and Social Issues in Science, Technology and Engineering

Key Stage 2

- Justify the merits and demerits of science, technology and engineering in society and the environment

Key Stage 3

- Plan project-based activities related to ethical, moral and social issues in applying the knowledge of science, technology and engineering

Sub-topic: Use of Information and Communication Technology (ICT)

Key Stage 1

- Explore the use of ICT tools (digital or electronic or mobile) tools to communicate and access information

Key Stage 2

- Explain the impact of (i.e. advantages and disadvantages) of ICT on society

Key Stage 3

- Implement usage of ICT to foster communication and networking
- Create or design an ICT gadget for a specific purpose that would benefit society

Sub-topic: Awareness on Cyber Security and Safety Issues

Key Stage 2

- Develop arguments on the various issues concerning cyber security and safety

Key Stage 3

- Conduct research and debate on cyber security and safety issues

Sub-topic: Ethical and Moral Issues on the Use of Technology in Genetic Research

Key Stage 3

- Describe the application of technology on the growth and development of plants and animals
- Use ICT to gather information on issues relating to genetic research
- Analyse the impact of genetic research on living organisms
- Develop arguments on the benefits and dangers of genetic research
- Assess and evaluate the usage of Genetically-Modified Organisms (GMO)

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